5(3)
283-285

KYOTO UNIVERSITY

PUBLICATIONS OF THE SETO MARINE BIOLOGICAL LABORATORY

Vol. V, No. 3

(Article 19 to 24)

OCT 1957
LIBRARY
POFI
FISH & WILDLIFE
SERVICE

SIRAHAMA, WAKAYAMA-KEN, JAPAN
PUBLISHED BY THE LABORATORY
December 1956

CONTENTS

Article *Page*

19. **Miyake, S.:** Invertebrate fauna of the intertidal zone of the Tokara Islands. XIII. Anomura. 303

20. **Utinomi, H.:** Invertebrate fauna of the intertidal zone of the Tokara Islands. XIV. Stony corals and hydrocorals. 339

21. **Yamanouchi, T.:** The daily activity rhythms of the holothurians in the coral reef of Palao Islands. 347

22. **Yaginuma, T.:** A new species of marine spider *Desis* from Japan. 363

23. **Tanaka, O.:** The pelagic copepods of the Izu region, middle Japan. Systematic account. II. Families Paracalanidae and Pseudocalanidae. 367

34. **Umezaki, I.:** Marine Cyanophyceae of Amami-Oshima Island. 407

All communications intended for the "Publications" should be addressed to the editor, Dr. H. Utinomi, The Laboratory, Sirahama, Wakayama Prefecture.

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

XIII. ANOMURA[1)2)]

SADAYOSHI MIYAKE
Zoological Laboratory, Faculty of Agriculture,
Kyushu University, Fukuoka

With 23 Text-figures

The biological expedition of the Osaka Municipal Museum of Natural History to the Tokara Islands, Kagoshima Prefecture was made during the period from May 25 to June 13, 1953.

I shall here report the Anomuran Crustacea collected by Dr. Takasi TOKIOKA of the Seto Marine Biological Laboratory and Mr. Shoichi MIYAMOTO of the Biological Laboratory, Kyushu University. The examination has revealed that these specimens fall in 15 species of five genera as listed below.

1. *Callianidea typa* H. MILNE EDWARDS
2. *Petrolisthes japonicus* (DE HAAN)
*3. *Petrolisthes unilobatus* HENDERSON
4. *Petrolisthes hastatus* STIMPSON
5. *Petrolisthes tomentosus* (DANA)
*6. *Clibanarius eurysternus* HILGENDORF
7. *Clibanarius corallinus* (H. MILNE EDWARDS)
8. *Clibanarius virescens* (KRAUSS)
*9. *Clibanarius zebra rhabdodactylus* FOREST
10. *Calcinus elegans* (H. MILNE EDWARDS)
11. *Calcinus laevimanus* (RANDALL)
12. *Calcinus gaimardi* (H. MILNE EDWARDS)
*13. *Calcinus terrae-reginae* HASWELL
14. *Calcinus latens* (RANDALL)
15. *Coenobita rugosus* H. MILNE EDWARDS

All of these species are unrecorded from Tokara Islands and four of them marked

1) Scientific Survey of the Tokara Islands, Report No. 30.
2) Contributions from the Zoological Laboratory, Faculty of Agriculture, Kyushu University, No. 229.

with an asterisk are new to the Japanese fauna.

I am especially indebted to Prof. Dr. Y. K. HIRAIWA of the Zoological Laboratory, Faculty of Agriculture, Kyushu University who has provided facilities require for the pursuit of this work. I express my hearty thanks to Dr. T. TOKIOKA and Mr. S. MIYAMOTO, for placing materials at my disposal. Acknowledgment is also due to Dr. H. UTINOMI of the Seto Marine Biological Laboratory, for his suggestions and sending me valuable papers not accessible to me.

Family CALLIANASSIDAE BATE, 1888

1. *Callianidea typa* H. MILNE EDWARDS, 1837

(Figs. 1–3)

New Japanese name: Erage-sunamoguri

Callianidea typa H. MILNE EDWARDS 1837, p. 320, pl. 25, f. 8-10–Bismark Is. (type-locality).
BORRADAILE 1898, p. 1015–Funafuti, Ellice Is.
DE MAN 1902, p. 751–Ternate.
BORRADAILE 1906, p. 752–Maldive Is.
NOBILI 1906, p. 113–Red Sea.
PESTA 1914, p. 678–Samoa.
BALSS 1914, p. 90–Tonga, E. Africa; Kagoshima; Yaéyama I.

Description. A female 38 mm in body-length from Takara-jima. Carapace much compressed, smooth, glabrous, nearly one-fourth of total length of the body; rostrum small, a little produced; the cervical groove and *linea thalassinica* distinct.

Eye-stalk 0.7 mm long, broad, much depressed, divergent proximally, and longer than first joint of antennal peduncle. Eye small, being situated on the outer side of the stalk. Antennule with biramous flagellae, each of them nearly equal, 7 mm long, one of these about 20–jointed with long, soft hairs only on one side, the other without hairs, about 30–jointed; its basal peduncle 3.6 mm long, with three joints; first joint 1.3 mm long containing otholith, a little longer than the second (1 mm), and equals to the third. Antennal peduncle 4.4 mm long, slender, four-jointed, 1, 3, 6 and 3 in the relative lengths; the flagellum of antenna 12 mm long, about 50–jointed, a little longer than 2.5 times as long as the peduncle.

Thoracic legs smooth, glabrous. Chelipeds unequal, with long hairs or setae on the margins; the right cheliped longer than the left one; ischium 5 mm long, rather slender, divergent distally; arm spindle-shaped, much swollen in the middle, and equals in length to ischium; wrist 1.8 mm long, very short, about twice as broad as long, divergent distally; palm 5.6 mm long, much compressed, very long, about three times as long as wrist; its posterior margin bears about 15 spinules; the immovable and movable fingers with two or three small teeth on the cutting margins, but their outer margins with long hairs; movable finger 5.6 mm long, much curved inwards, so that tips of fingers cross over to each other. The left cheliped rather slender,

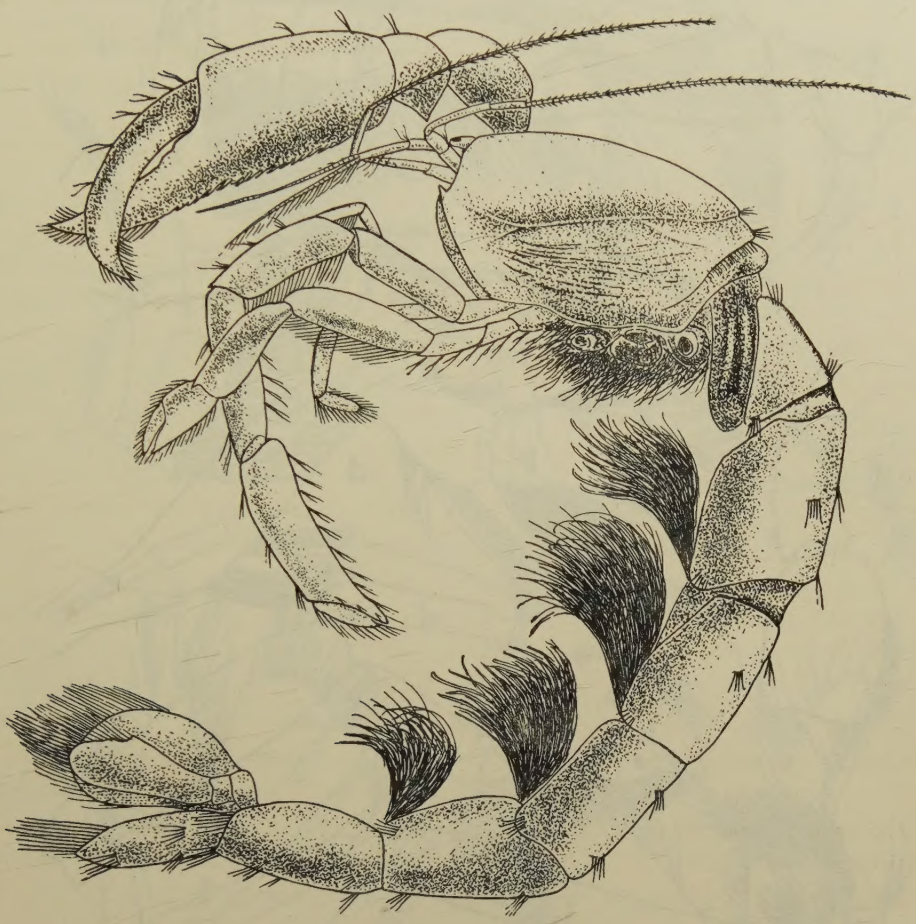


Fig. 1. Lateral view of *Callianidea typa* H. MILNE EDWARDS, ×5.

much compressed; arm 3.5 mm long, a little shorter than ischium (4 mm), its upper margin with three tufts of hairs, but the lower distal margin beset with short hairs; the lower margins of wrist and palm bear fine, closely-set tufts of hairs; the upper margins of palm and movable finger with long hairs thickly.

Second thoracic leg chelate, 13 mm in whole length; upper and lower margins of all joints, except on upper margin of merus, with soft, long hairs thickly; proportions of dactylus, carpus, merus and ischium are 10 : 9 : 12 : 27 : 7. The third leg 13 mm, subchelate, same length of second one; dactylus 1.5 mm long, rather small, articulated with propodus at the middle of the distal margin; propodus 3 mm long, very broad, almost as broad as long, with scattered tufts of short hairs on outer surface, with long hairs on distal and lower margins, armed with an acute tooth on inner distal angle forming a small cheliped with the dactylus; carpus 2.7 mm long, divergent distally, with three tufts of hairs, two of them on upper margin, the other

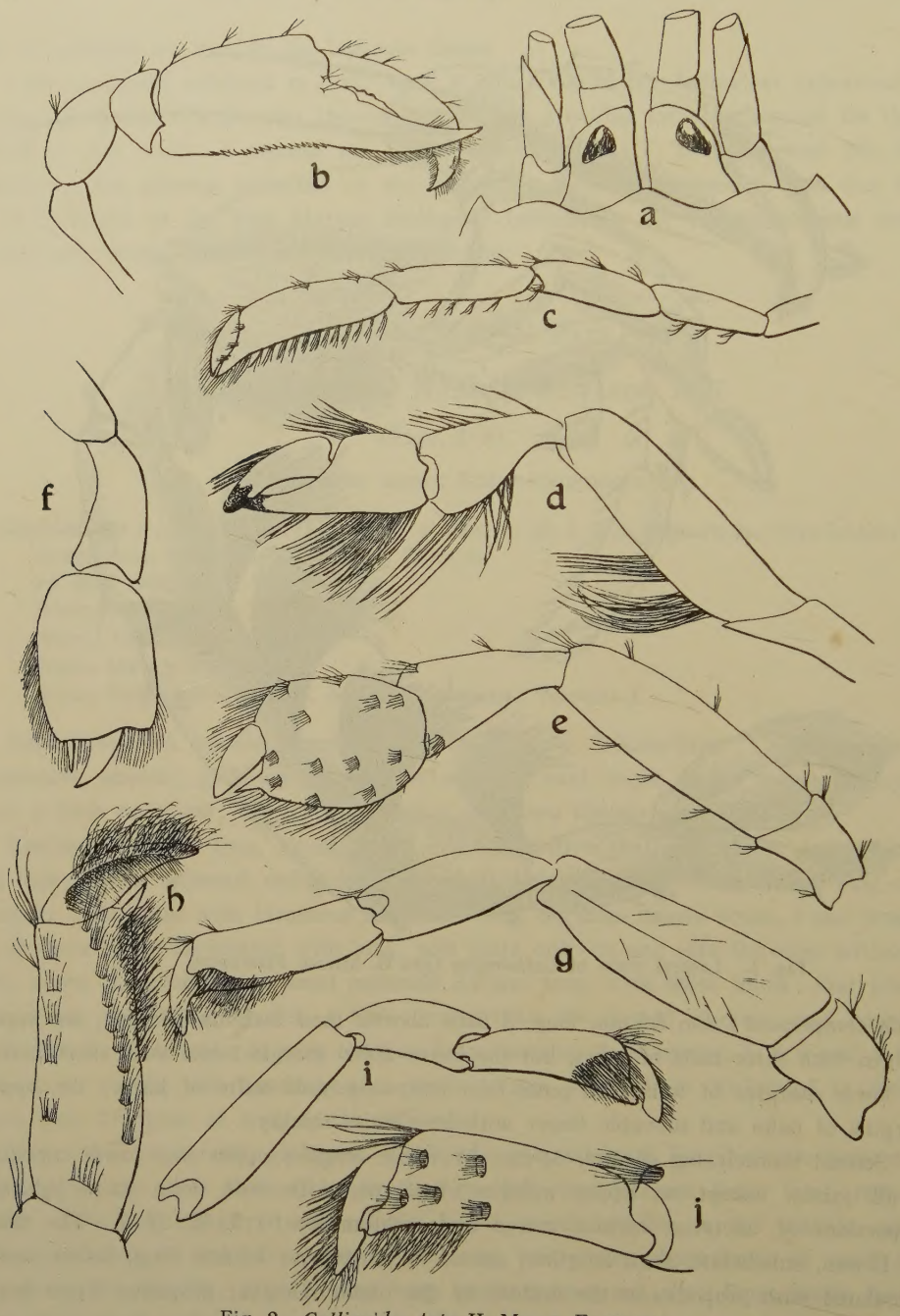


Fig. 2. *Callianidea typa* H. MILNE EDWARDS.
a, Upper view of frontal region, ×14. b, outer view of right cheliped, ×4. c, outer view of left cheliped, ×4. d, upper view of left second leg, ×7. e, upper view of left third leg, ×7. f, lower view of tip of the same, ×7. g, lower view of right fourth leg, ×7. h, upper view of tip of the same, ×14. i, lower view of right fourth leg, ×7. j, upper view of tip of the same, ×14.

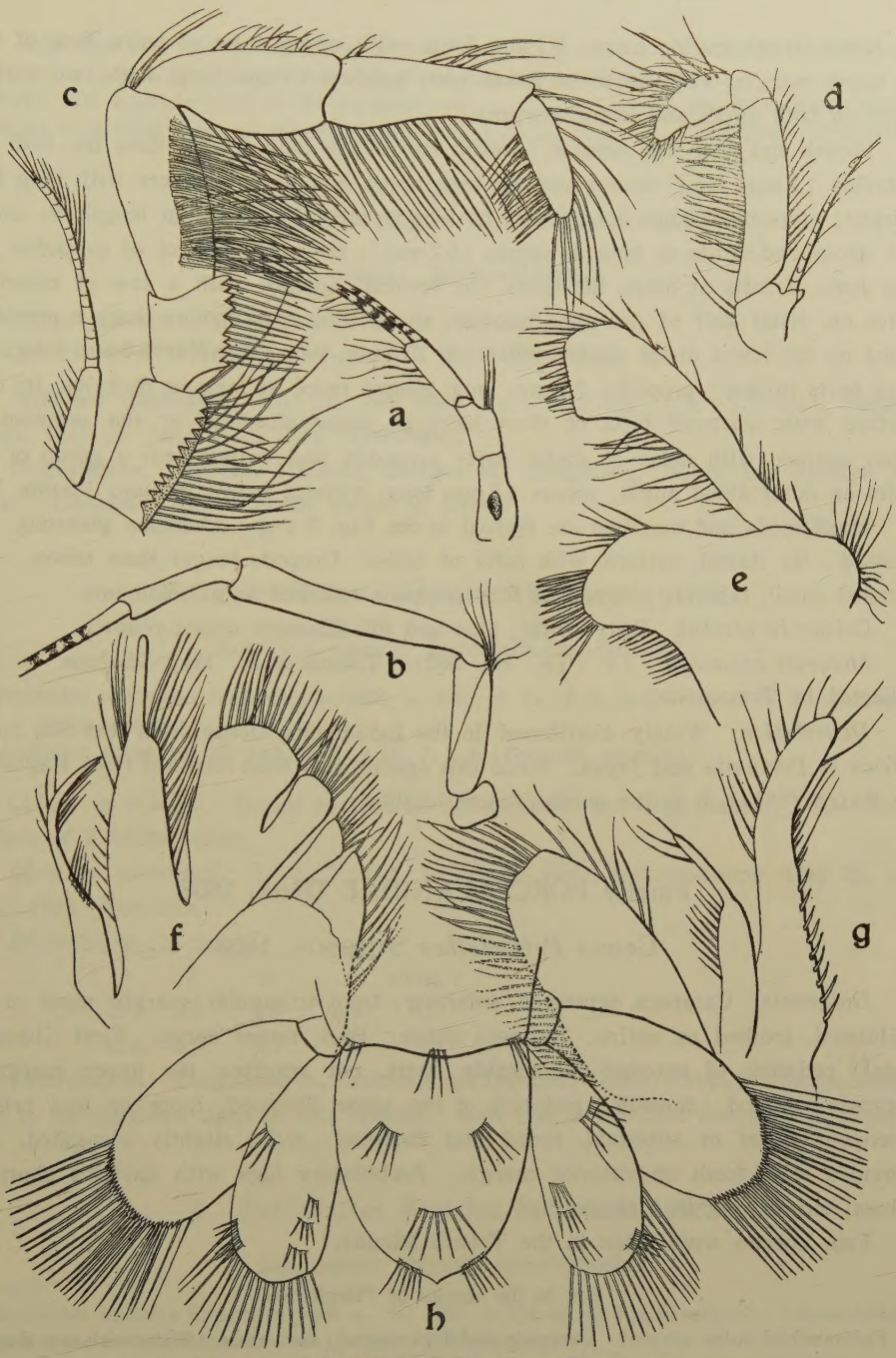


Fig. 3. *Callianidea typa* H. MILNE EDWARDS.
a, Peduncle of antennule, ×10. b, basal peduncle of antenna, ×14. c, lower view of left third maxilliped, ×14. d, upper view of left second maxillped, ×14. e, upper view of left first maxilliped, ×30. f, upper view of left second maxilla, ×30. g, upper view of left first maxilla, ×30. h, upper view of telson and uropods. ×7.

on lower distal angle; merus 5.1 mm long, with seven tufts of hairs, four of them on upper margin, while three on lower one; ischium 1.7 mm long, with two tufts of hairs on both upper and lower margins.

Fourth and fifth legs normal. Fourth leg 15 mm long, longer than the fifth leg; dactylus 1.7 mm long, ornamented on both upper and lower surfaces with long hairs thickly; propodus 3.4 mm long, twice as long as dactylus, equal in length to carpus, but about two-thirds as long as merus (5.2 mm); the outer surface of propodus with two rows of tufts of hairs, the inner (or ventral) surface with a row of closely-set hairs on distal half of posterior margin; in addition to propodus bears a prominent spine on the lower distal angle. Fifth leg 13.5 mm long; dactylus 1.7 mm long, with long hairs thickly; propodus 3.3 mm long, almost twice as long as dactylus, its outer surface with scattered tufts of short hairs on distal one-third of the segment, its inner surface with setae at distal part; propodus and carpus bear a group of long hairs on outer distal angle; merus 4.3 mm long, without hairs; ischium 1.5 mm long.

Maxillipeds and maxillae are figured in the Fig. 3 c–g. Abdomen glabrous, compressed; its dorsal surface with tufts of setae. Uropods longer than telson. First pleopod small, tapering; second to fifth pleopods attached to gill-filaments.

Colour in alcohol. Body white; legs and gill-filaments cream-yellow.

Material examined. 1♀ (TK. No. 562), Takara-jima, May 25–June 1, 1953, collected by TOKIOKA.

Distribution. Widely distributed in the Indo-Pacific Ocean from Red Sea and E. Africa to Polynesia and Japan. Since this species has been recorded from Kagoshima by BALSS (1914), it is the northern-most locality.

Family PORCELLANIDAE DANA, 1858

Genus *Petrolisthes* STIMPSON, 1858

Diagnosis. Carapace depressed, subovate; front triangular, margin more or less undulated, toothed or entire. Epimera entire. Eyes rather large. First (basal or coxal) peduncle of antenna remarkably short, not reaching the upper margin of carapace; second (movable) peduncle of the same flattened, more or less cristate. Chelipeds equal or subequal, broad and flattened; wrist slightly elongated, often provided with teeth on anterior margin. Ambulatory legs with dactylus short and robust, terminating in a single claw.

Four species were taken in the Tokara Islands.

Key to the species of *Petrolisthes*

1 Epibranchial spine present. Carapace and legs sparsely tomentose. Wrist with saw-shaped teeth on anterior margin. Propodus of first three ambulatory legs with four spinules on posterior margins ..... *P. tomentosus* (DANA)

– Epibranchial spine wanting. Carapace and legs almost smooth 2

2 Posterior margin of wrist with two or three teeth. Propodus of first three ambulatory

legs with five spinules on posterior margin ..... *P. japonicus* (DE HAAN)
– Posterior margin of wrist prolonged at distal end into acute spine 3
3 Wrist with a single tooth at the proximal end ..... *P. unilobatus* HENDERSON
– Wrist with three teeth on anterior margin ..... *P. hastatus* STIMPSON

2. *Petrolisthes japonicus* (DE HAAN, 1849)

Jap. name: Iso-kanidamashi

Porcellana japonica DE HAAN 1849, p. 199, pl. 50, f. 5–Japan.
Petrolisthes japonicus MIYAKE 1943, p. 73, f. 11–13 (Synonymy).

Material examined. 1 ♂ (TK. No. 563) (c. l. = 8.2 mm; c. b. = 7.9 mm), Nakano-shima, May 25, June 3–13, 1953 (TOKIOKA).

Distribution. Borneo, Malacca, Mergui Is., Hongkong, Bonin Is., Ryukyu and Japan. Commonly found under stones in Japan.

3. *Petrolisthes unilobatus* HENDERSON, 1888

New Jap. name; Togenashi-kanidamashi

Petrolisthes unilobatus HENDERSON 1888, p. 106, pl. 11, f. 3, 3a–Off Nukalofa, Tongatabu Is. (type-locality).
Petrolisthes unilobatus MIYAKE 1943, p. 66, f. 7, 8 (Formosa, Ryukyu).

Colour in alcohol. Dorsal surface of the carapace and legs reddish; the ventral surface of a white colour.

Material examined. 3 ♂ ♂, 1 ovig. ♀ (TK. No. 564), Nakano-shima, May 25, June 3–13, 1953 (TOKIOKA).

Dimensions (in mm).

	♂	♂	♂	ovig. ♀
c. l.	5.6	6.8	8.0	6.5
c. b.	5.6	6.7	7.3	6.5

Distribution. Tongatabu Is., Formosa and Okinawa-Hontō, Ryukyu. Nakano-shima Islet is the northern limit of this species. And this is the first record from Japan.

4. *Petrolisthes hastatus* STIMPSON, 1858

Jap. name: Minami-kanidamashi

Petrolisthes hastatus STIMPSON 1858, p. 79; 1907, p. 184, pl. 22, f. 4–Kikai-jima; Amami-Oshima.
Petrolisthes hastatus MIYAKE 1943, p. 62, f. 5–6 (Synonymy).
Petrolisthes hastatus MIYAKE 1949, p. 742, f. 2146.

Material examined: 2 ♂ ♂, 2 ♀ ♀, 2 ovig. ♀ ♀ (TK. No. 565), Takara-jima, May 26–June 1, 1953 (TOKIOKA).

Dimensions (in mm).

	♂	♂	♀	♀	ovig.♀	ovig.♀
c. l.	6.5	8.3	6.2	6.6	7.5	10.9
c. b.	6.4	8.0	6.0	6.6	7.0	11.5

Distribution. From Nicobars to Bismark Islands. Takara-jima is the northern limit of this species.

5. *Petrolisthes tomentosus* (DANA, 1852)

Jap. name: Kebuka-kanidamashi

Porcellana tomentosa DANA 1852, p. 420; 1855, pl. 26, f. 10–Raraka I., Paumotu Is. (type-locality).
Petrolisthes tomentosus MIYAKE 1943, p. 85, f. 19–21 (Synonymy).
Petrolisthes tomentosus MIYAKE 1949, p. 742, f. 2147.

Material examined. 1 ovig. ♀ (TK. No. 566) (c. l. = 6.8 mm, c. b. = 6.8 mm), Nakano-shima, May 25, June 3–13, 1953 (TOKIOKA).

Distribution. Paumotu Is., Bonin Is., Ryukyu (Ishigaki-jima), Amami-Oshima, Meshima Islet, Danjo-Group (northern limit) and above-mentioned locality.

Family PAGURIDAE DANA, 1852

6. *Clibanarius eurysternus* HILGENDORF, 1878

(Figs. 4–5)

New Jap. name: Hirakō-yokobasami

Pagurus (*Clibanarius*) *eurysternus* HILGENDORF 1878, Monatsb. Akad. Wissensch., p. 822, pl. 3, f. 9-10–Mozanbique, E. Africa (type-locality) (not seen).
Clibanarius eurysternus FIZE et SERÈNE 1955. p. 118, f. 17 (Synonymy).

Description. The coxae of fifth thoracic legs, owing to depressed and deflexed carapace, are wide apart. This peculiar form of the carapace is a special adaptation for the occupation of the narrow cavities of shell of the Strombidae. It is easily distinguished from other members of the genus by the flattened carapace.

Eye-stalk excluding eye a little shorter than anterior border of carapace, but distinctly longer than antennal peduncle. Antennal acicle armed with four spinules, one of them on the outer and three on the inner margins. It reaches one-third of the last joint of antennal peduncles.

Cheliped subequal, spinulose, setose; arm with two acuminate teeth on upper outer margin; wrist with one spine on upper inner margin; palm a little shorter than fingers, provided on upper surface with thorn-like tubercles and hairs; of which four or five tubercles on inner border and five ones on inner margin of immovable finger are most prominent. Fingers with three teeth on each cutting margin, two of them on the proximal part small, but the other on the distal part large.

Fig 4. *Clibanarius eurysternus* HILGENDORF.
a, Upper view of cephalothorax, ×8. b. upper view of left cheliped, ×16. c, lower view of the same, ×16. d, outer view of left third leg, ×10.

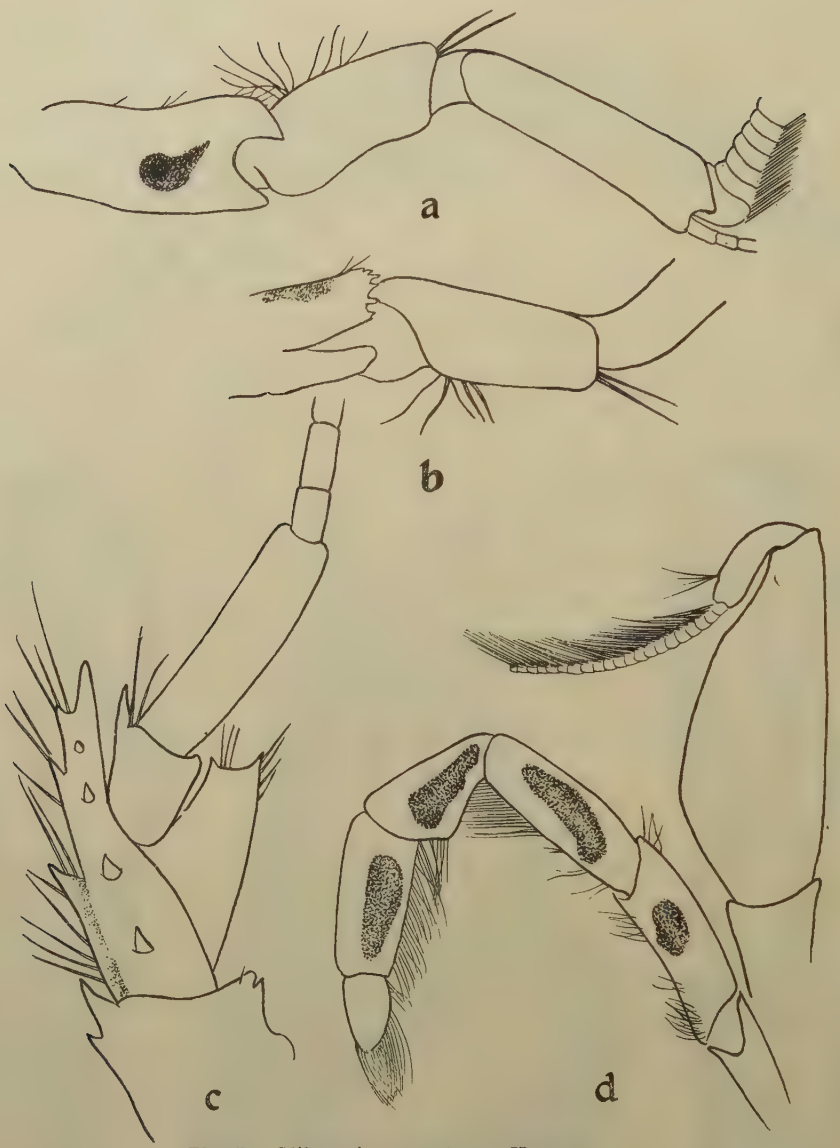


Fig. 5. *Clibanarius eurysternus* HILGENDORF.
a, Upper vitw of left antennule, ×33. b, lateral view of the same, ×33. c, upper view of left antenna, ×33. d, upper view of left third maxilliped. ×33.

Second and third legs rather compressed, ornamented with tufts of long hairs; carpus with a spine on distal border; dactylus distinctly longer than propodus, armed on inner margin with 10–12 spinules.

Colour in life. Ground colour of the carapace yellowish white. The anterior parts marked with four red-brown stripes longitudinally (after TOKIOKA's observation).

Colour in alcohol. Anterior parts of carapace, eye-stalk, peduncles of antennule

and antenna, and third maxilliped marked with red-brown stripes as in the text-figures.

Material examined.

Nakano-shima, 1 ♀ (TK. No. 567) (e), June 2–13, 1953 (Tokioka).

Takara-jima, 1 ♂ (TK. No. 568) (a), 3 ♀ ♀ (b, c, d), May 25–June 1, 1953 (Tokioka).

Dimensions (in mm).

	♂ (a)	♀ (b)	♀ (c)	♀ (d)	♀ (e)
c. l.	6.2	7.2	9.0	8.0	8.3
c. b.	6.2	6.5	8.5	7.0	8.3

Distribution. Tokara Islands: Nakano-shima (northern limit), Takara-jima; and Indo-West Pacific region. This species has not been described from Japanese waters.

7. *Clibanarius corallinus* (H. Milne Edwards, 1848)

(Figs. 6–7)

New Jap. name: Minami-yokobasami

Fig. 6. *Clibanarius corallinus* (H. Milne Edwards), ×2.

Pagurus corallinus H. MILNE EDWARDS 1848, Ann. Sci. Nat., ser. 3, vol. 10, p. 63–New Guinea, type-locality (not seen).
Clibanarius corallinus TERAO 1931, p. 360; 1914, p. 181, fig.–Nakano-shima, Tokara Islands.
Clibanarius globosimanus STIMPSON 1858, p. 85; 1907, p. 210–Loo Choo (Okinawa-Hontō).

Description. Carapace slightly convex in both directions, longer than broad, the proportion of length to breadth being 3 : 2; upper surface punctate especially in posterior part; its lateral margins ornamented with tufts of hairs.

Eye-stalk excluding eye as long as anterior border of carapace, and a little longer than antennular peduncles. Basal peduncles of antennule slender, very long, the

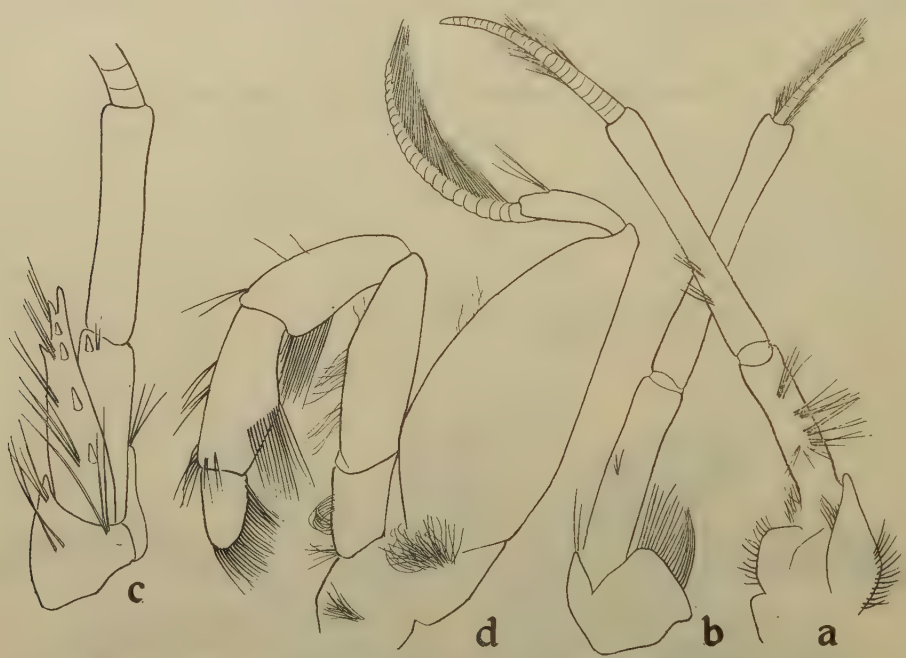


Fig. 7. *Clibanarius corallinus* (H. MILNE EDWARDS).
a, Upper view of left antennule, ×25. b, lower view of the same, ×25. c, upper view of left antennule, ×25. d. lower view of left third maxilliped, ×12.

proportion of the segments being 3 : 4 : 7. Antennal acicle with six spinules, two of them on outer margin, four spinules on inner one, superpassing the proximal end of last joint of the antennal peduncles. The penultimate joint (basipodite) with a spinule on inner angle.

Chelipeds subequal; merus with two acute teeth at the distal end of outer lower margin and with minute, acute teeth or spinules on inner lower edge and upper distal margin. The upper surface of wrist, hand and fingers armed with thorn-like tubercles bordering tufts of setae.

Second and third pairs subcylindrical, smooth and sparsely setose; ischium and merus much compressed, ornamented on both upper and lower borders with tufts of

setae; carpus with a spine at distal end of upper surface; propodus provided on the distal end of both inner and outer margins with a small spine; the outer surface of propodus of left leg of the third pair much flattened, bearing closely-set tufts of long setae; dactylus distinctly shorter than propodus. Fourth pair much compressed, ornamented on both upper and lower margins with tufts of hairs.

Colour in life. Body of a dark brown-purple colour. Eye-stalk marked with reddish brown lines.

Colour in alcohol. Carapace brownish purple in anterior half, while bluish white in posterior half. Eye-stalk whitish except reddish proximal part. Peduncles of antennule and antenna reddish brown. Merus and carpus of thoracic legs brown-purple; propodus and dactylus dark red.

Material examined.

Nakano-shima, 1 ♂, 1 ♀ (TK. No. 569), May 25, June 3–13, 1953 (Tokioka).

Takara-jima, 6 ♂ ♂, 11 ♀ ♀ (TK. Nos. 570, 571), May 26–June 1, 1953 (Tokioka).

Dimensions (in mm).

	largest ♂	largest ♀
c. l.	19.5	18.5
c. b.	12.0	12.0

Distribution. Mergui Archipelago, Bonin Islands, Formosa; Japan: Amami-Oshima, Tanega-shima and above-mentioned localities. This species, according to Dr. T. Tokioka, is found very commonly in Tokara Islands. Tanega-shima is the northern limit of this species.

8. *Clibanarius virescens* (Krauss, 1843)

(Figs. 8–9)

Jap. name: Iso-yokobasami

Pagurus virescens Krauss 1843, Die Südafrikanische Crustacea, p. 56, pl. 4, f. 3–Natal, type-locality (not seen).
Clibanarius virescens Buitendijk 1937, p. 263–Australasiatic Seas.
Clibanarius bimaculatus Ortmann 1892, p. 291–Tokyo Bay, Sagami Bay.
Clibanarius bimaculatus Balss 1913, p. 41, f. 28–Satsuma, Southern Kyushu; Formosa.
Clibanarius bimaculatus Terao 1913, p. 360; 1914, p. 109, f. –Satsuma.
Clibanarius bimaculatus Miyake 1949, p. 739, f. 2136–Japan.

Description. Carapace depressed; its greatest breadth equal to about two-thirds the length; the upper surface naked, glabrous, with tufts of bristles in posterior half.

Eye-stalk excluding eye a little longer than anterior border of carapace, but slightly shorter than antennular peduncles. Antennal acicle slender, setose, with two spinules only on inner margin, reaching beyond the proximal end of last joint of antennal peduncles.

Chelipeds almost equal in both sexes; arm provided with an acute tooth at distal end of upper margin; palm and fingers thickly beset with thorn-like tubercles on

Fig. 8. *Clibanarius virescens* (KRAUSS), ×5.

upper surfaces.

Second and third legs smooth, glabrous, furnished with tufts of setae and long hairs sparsely. There is a distinct ridge separating the upper and outer surface only in the left propodus of the third pair.

Remarks. ORTMANN (1892, p. 291) and BALSS (1913, p. 14) have described *Clibanarius bimaculatus* (DE HAAN) from Japan. BUITENDIJK (1937, p. 264), however, has identified them as *C. virescens* (KRAUSS) by the following characters after her revision of the material deposited in the Strassbourg Museum and in the collection in München. According to her description, they agree with each other and differ from DE HAAN's description in having spines on the palm of the chelipeds and a ridge separating the upper and outer surfaces of the propodus of the third leg. Already TERAO (1913) has stated that the materials from Kagoshima, Southern Kyushu, differ from DE HAAN's original description by having almost equal chelipeds.

Colour in life. Carapace bluish with numerous minute spots of a white colour in most parts, but brownish purple in anterior third. Eye-stalk, ophthalmic scale, antennule

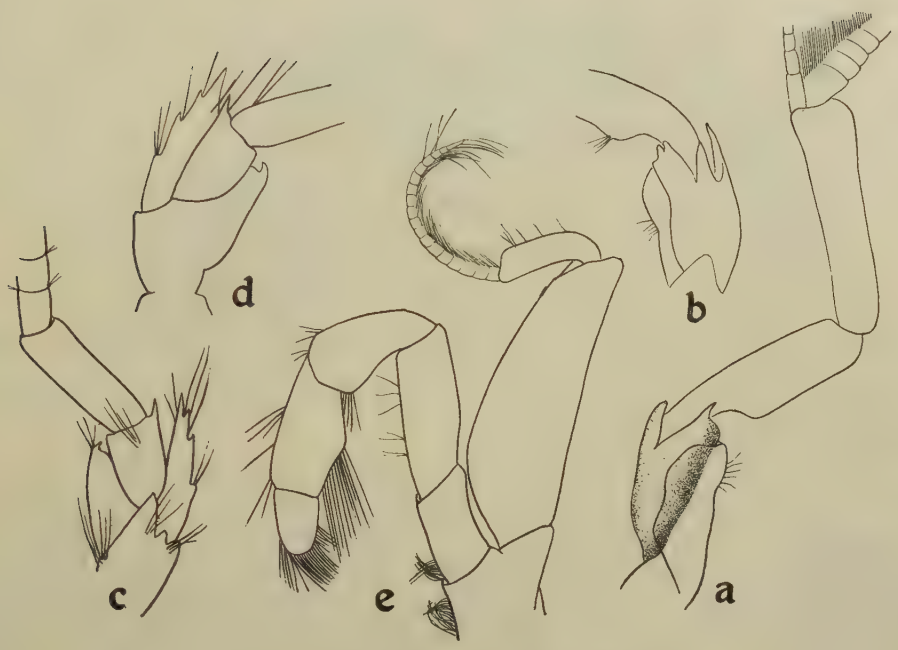


Fig. 9. *Clibanarius virescens* (KRAUSS).
a, Lower view of left antennule, ×40. b, upper view of the same, ×40. c, upper view of left antenna, ×40. d, lower view of the same, ×40. e, lower view of left third maxilliped, ×40.

and antenna reddish brown. Cheliped reddish brown; fingers greenish gray; tips of fingers black. Second and third legs brownish purple, with two whitish cross-bands on distal and proximal ends of dactyli; the proximal cross-band is somewhat brownish and broader than the distal one. The distal ends of propodi of second and third legs furnished with the same coloured cross-band as that in the proximal ends of dactyli. Fourth and fifth thoracic legs greenish gray. Abdomen whitish (after TOKIOKA's note).

Material examined.

Nakano-shima, 3♂♂, 1 ovig.♀ (TK. No. 572), May 25, June 3–13, 1953 (TOKIOKA).

Takara-jima, 4♂♂, 3♀♀, 5 ovig.♀♀ (TK. No. 573), May 26–June 1, 1953 (TOKIOKA).

Dimensions (in mm)

Nakano-shima

	♂	♂	♂	ovig.♀
c.l.	5.0	5.3	6.0	5.3
c.b.	3.0	3.5	3.8	3.3

Takara-jima

	♂	♂	♂	♂	♀	♀	♀	ovig.♀	″♀	″♀	″♀	″♀
c.l.	2.8	4.5	5.0	6.0	4.0	4.2	4.5	2.5	2.8	3.0	3.5	3.8
c.b.	2.0	2.5	3,8	4.3	3.0	2.8	3.0	1.8	2.0	2.0	2.8	2.8

Since the smallest egg-laden female measures 2.5 mm in the length of carapace, this species from Tokara Islands seems to be a smaller member of the genus.

Distribution. From W. and S. E. Africa eastwards to Fiji Islands and as far as Japan. Its northern limit, according to the records, is Tokyo Bay.

9. *Clibanarius zebra rhabdodactylus* FOREST, 1953

(Figs. 10–11)

New Jap. name: Akatsume-yokobasami

Clibanarius zebra rhabdodatylus FOREST 1953, p. 448, f. 3, 8–Hikueru I., Polynesia (type-locality).

Description. Carapace naked, punctate on upper surface; rostrum small, triangular, being longer than the lateral angles.

Eye-stalk including eye rather stout and as long as antennular peduncle. Ophthalmic scale large, with three minute spinules near the apex. Antennal peduncle reaches the base of the eye; antennal acicle unarmed, rather small, slender from its base, being a little longer than the first joint of the peduncle. The third maxilliped with slender endopodite and broad exopodite; carpus and merus of the endopodite with soft, long hairs on inner margins, but without spines on both inner and outer margins.

Cheliped unequal; right hand a little larger in the male; the upper surface with spiniform tubercles and tufts of setae. First and second ambulatory legs compressed, ornamented with hairs sparsely; merus very broad proximally and with hairs on both upper and lower margins; propodus twice as long as dactylus and with tufts of hairs on upper margin; dactylus with three spinules tufts of hairs on inner margin.

Colour in alcohol. Ground colour of the body light orange. Eye-stalk, carapace and legs marked with red-brown stripes. Eye-stalk with a broad, longitudinal stripe on dorsal surface. Carapace with four logitudinal bands on the surface; first and second ambulatory legs with five stripes, three of them on the outer surface of each segment. Ophthalmic scale and cheliped, however, of an uniform red-brown colour on dorsal surface.

It is easily distiguished by the following character. The typical species, *Clibanarius zebra* DANA has no stripe only in the dactyli of ambulatory legs.

Material examined.

Takara-jima, 2 ♂ ♂ (TK. No. 574), May 26–June 1, 1953 (TOKIOKA).

Dimensions (in mm)

	♂	♂
c. l.	7	6
c. b.	4	4

Distribution. Polynesia, Indonesia and above-mentioned locality. This is the first record in Japanese fauna.

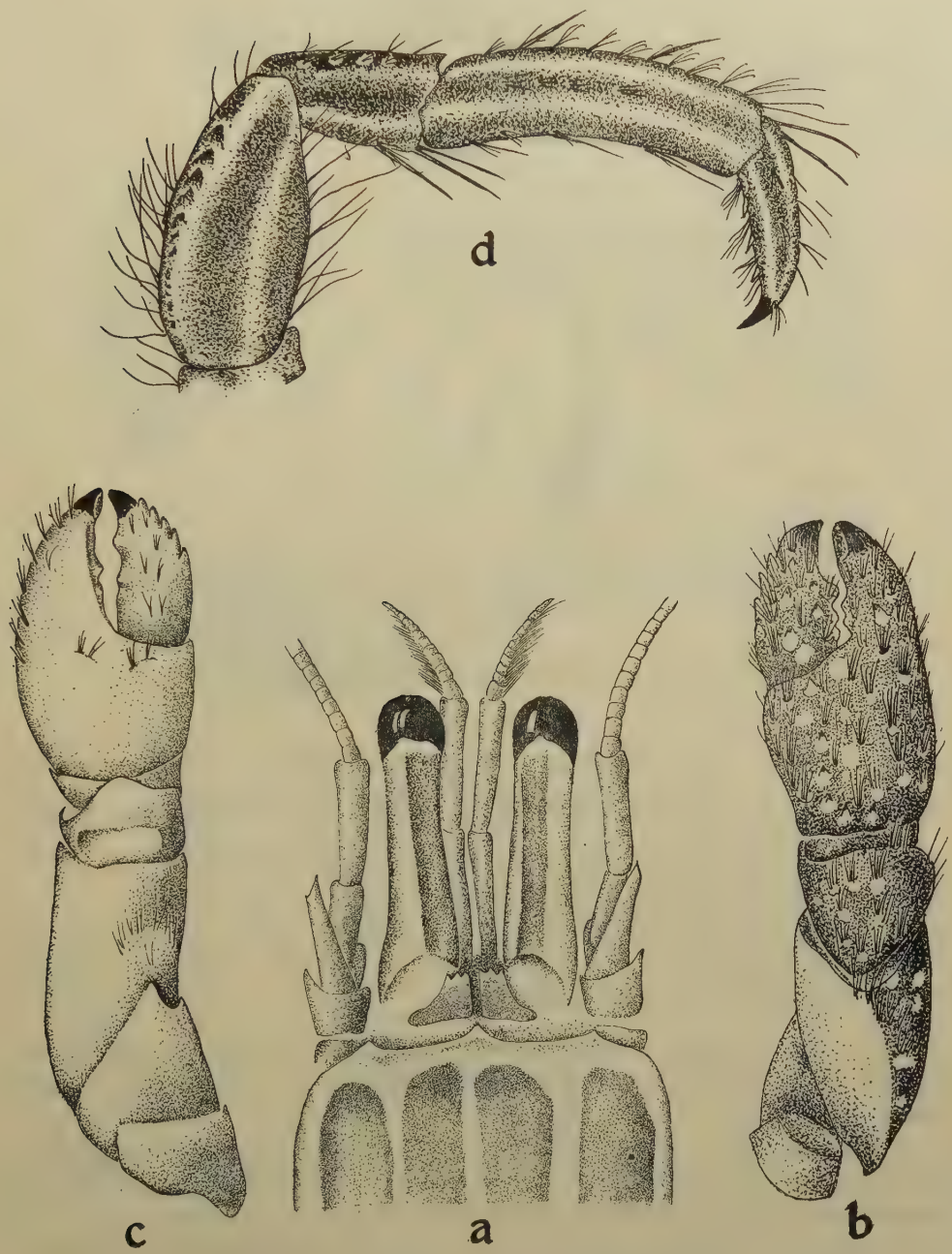


Fig. 10. *Clibanarius zebra rhabdodactylus* FOREST.
a, Frontal region, ×20. b, upper view of right cheliped, ×13. c, lower view of the same, ×13. d, outer view of right second ambulatory leg, ×13.

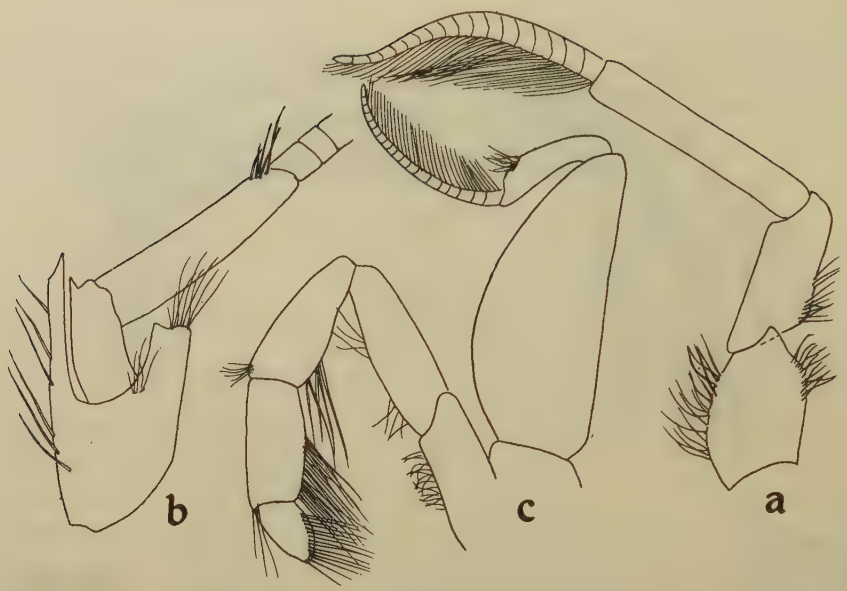


Fig. 11. *Clibanarius zebra rhabdodactylus* FOREST.
a, Lower view of left antennule, ×25. b, lateral view of left antenna, ×25.
c, lower view of left third maxilliped, ×25.

10. *Calcinus elegans* (H. MILNE EDWARDS, 1836)

(Figs. 12–13)

New Jap. name: Wamon-sangoyadokari

Pagurus elegans H. MILNE EDWARDS 1836, p. 278, pl. 13, f. 2, 2a–Nouvelle-Irlande (Bismarck Islands, type-locality).
Calcinus elegans STIMPSON 1858, p. 85–Ad insulam Loo Choo (Okinawa-Hontō).
Calcinus elegans TERAO 1913, p. 357–Miyano-ura, Tanega-shima.
Calcinus elegans NAKAZAWA 1927, p. 1041, f. 2004–South Sea.
Calcinus elegans SHIINO 1933, p. 259–Seto, Prov. Kii (infested by a Bopyrid, *Parapagurion calcinicola* SHIINO).
Calcinus elegans MELIN 1939, p. 21–Bonin Islands.

Description. Carapace rather depressed, smooth, well calcified in anterior half, furnished on lateral margins and behind cervical groove with tufts of long, purplish hairs.

Eye-stalk excluding eye as long as anterior border of carapace, slightly longer than or almost equal to antennular peduncle, and much longer than antennal peduncle. Antennal acicle with six spinules, two of them on outer margin, four on inner one, reaching beyond the proximal end of the last joint of antennal peduncle. Ophthalmic scale triangular, with tip pointed.

Cheliped smooth, unequal; left one much larger; merus with three spines at distal end of outer lower margin in both chelipeds; carpus of left side provided on

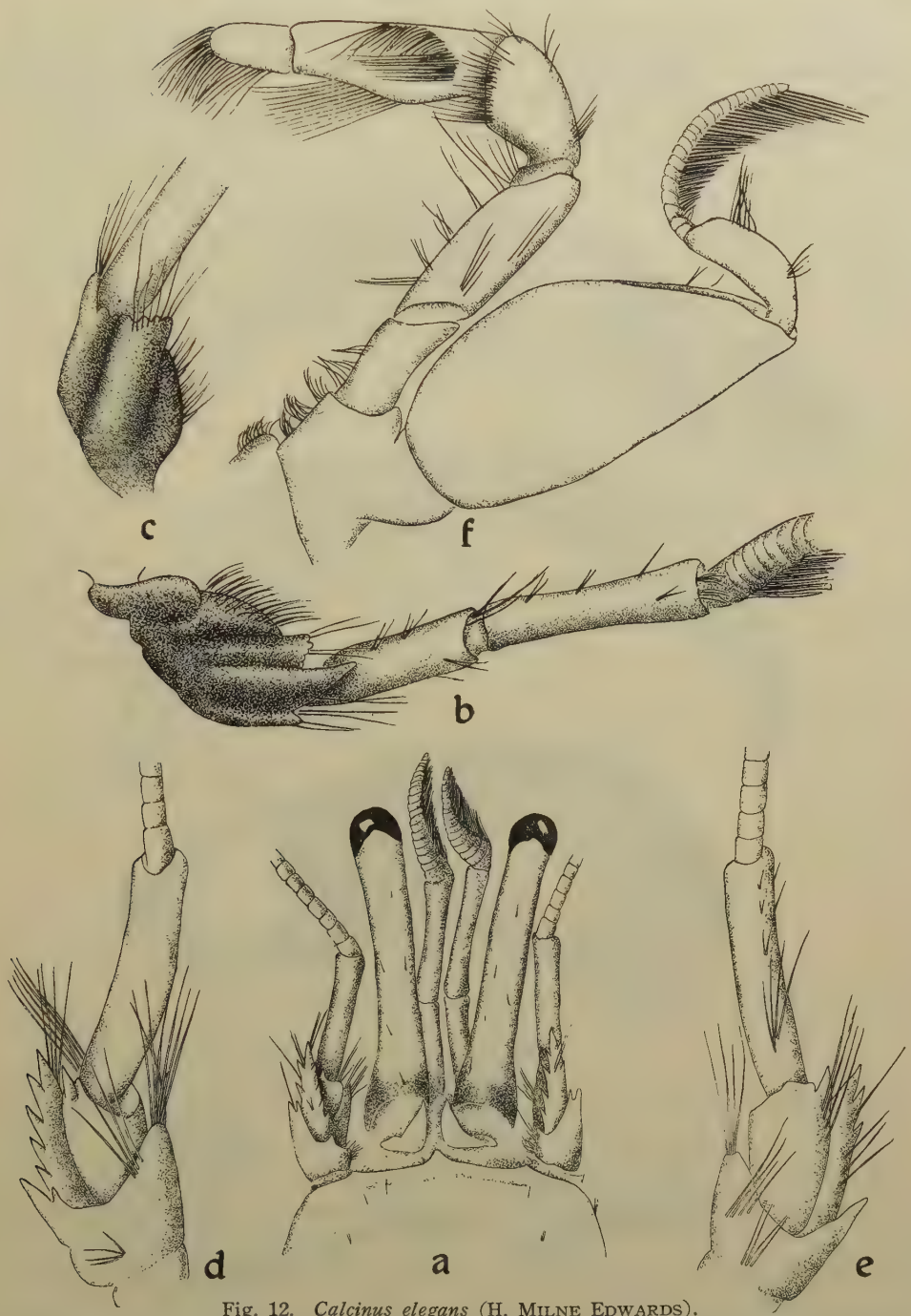


Fig. 12. *Calcinus elegans* (H. MILNE EDWARDS).
a, Frontal region, ×10. b, upper view of left antennule, ×33. c, lower view of coxopodite of the same, ×33. d, lower view of the basal peduncle of left antenna, ×33. e, upper view of the same, ×33. f, lateral view of left third maxilliped, ×16.

upper surface with an oblique groove; palm stout, smooth, unarmed; dactylus and immovable finger as long as palm, covered with white, pearl-like granules on the surface, furnished on inner margin with tufts of short hairs; dactylus with three teeth on cutting margin. There is a gap between fingers. Right cheliped much com-

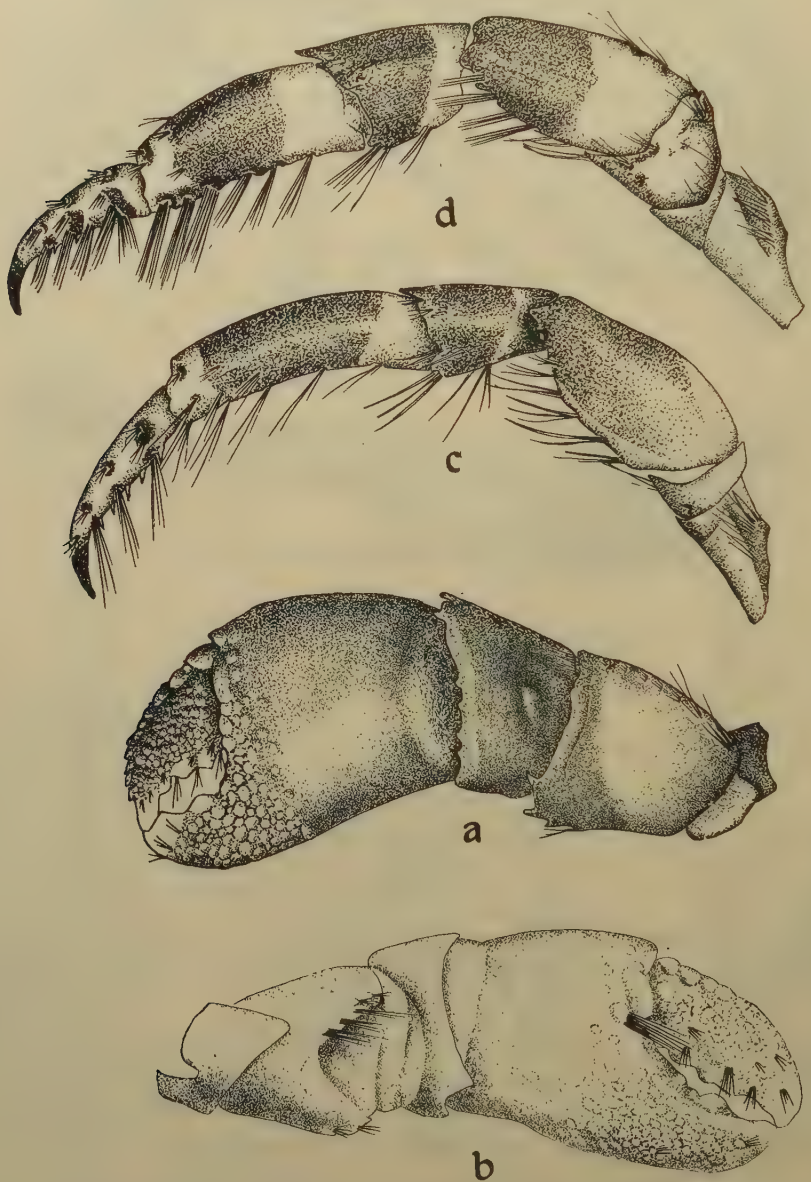


Fig. 13. *Calcinus elegans* (H. MILNE EDWARDS).
a, Upper view of left cheliped, ×10. b, lower view of the same, ×10. c, upper view of left second leg, ×4. d, upper view of left third leg, ×4.

pressed, its upper border acuminate; carpus with an acuminate tooth at distal end of upper margin; palm and immovable finger also with acute teeth on upper margin; fingers covered with the similar granules, but they are fewer as in left cheliped, tips of which pointed. Second and third legs smooth, almost equal to the larger cheliped, furnished on posterior margin with tufts of purplish hairs, especially dactylus and distal half of propodus of the third legs furnished with closely-set long setae.

Colour in life. Carapace white. Eye-stalk pale blue. Ophthalmic scale and proximal end of eye-stalk reddish. Antennule and antenna orange-yellow. Cheliped dark brown excepting fingers with white pearl-like tubercles. Second and third legs marked with alternate broad and narrow cross-bands; the narrow one blue. Dactylus blue with blackish purple spots. Hairs claret (after TOKIOKA's observation).

Colour in alcohol. Carapace yellowish. Eye-stalk light red. Base of eye-stalk and ophthalmic scale reddish yellow. Antennule and antenna orange. Cheliped yellowish brown with white tubercles. Second and third legs with dark red, broad cross-bands and whitish narrow bands. Dactylus whitish with the similar dark red spots. Hairs purple.

Material examined.

Nakano-shima, 1 ovig. ♀ (TK. No. 575), June 2–13, 1953 (TOKIOKA).

Takara-jima, 14 ♂♂, 6 ♀♀, 1 ovig. ♀ (TK. No. 576), May 26–June 1, 1953 (TOKIOKA).

Dimensions (in mm).

	largest ♂	largest ♀	ovig. ♀	ovig. ♀
c. l.	13.0	10.0	6.5	8.7
c. b.	10.0	7.3	4.0	6.5

Distribution. Widely distributed in the Indo-Pacific region.

11. *Calcinus laevimanus* (RANDALL, 1839)

(Figs. 14–15)

Jap. name: Subesube-sangoyadokari

Calcinus tibicen STIMPSON 1858, p. 85–Amami-Oshima; Loo Choo (Okinawa-Hontō), Bonin Islands.

Calcinus herbsti ORTMANN 1892, p. 292–Amami-Oshima.

Calcinus tibicen STIMPSON 1907, p. 208–No new locality.

Calcinus laevimanus TERAO 1913a, p. 358–Naze, Amami-Oshima; Naha, Okinawa-Hontō; Koshun, Formosa.

Calcinus laevimanus TERAO 1913b, p. 591, f. 3, 3a–above-mentioned localities.

Calcinus herbsti NAKAZAWA 1927, p. 1040, f. 2003–Ryukyu; South Sea.

Calcinus herbstii SHIINO 1933, p. 263–Seto, Prov. Kii (infested by a Bopyrid, *Propseudione rhombicosoma* SHIINO).

Calcinus laevimanus NAKAZAWA 1949, p. 739, f. 2138–Amami-Oshima, Ryukyu, Formosa, Bonin Islands, South Sea.

Description. Carapace smooth, somewhat punctate; its greatest breadth longer than two-thirds of the length. Eye-stalk excluding eye a little shorter than anterior

borber of the carapace, almost equal to antennular peduncle, and longer than antennal peduncle. Ophthalmic scale triangular with tip acuminate. Antennal acicle with a spinule on outer margin, reaching the distal end of penultimate joint of the antennal peduncle.

Cheliped smooth, unequal; the left cheliped much more massive than the right one; wrist of the left cheliped with an oblique groove on upper surface; palm very large, nearly as long as broad, and a little longer than movable finger of a female from Nakano-shima; immovable finger with an obtuse tooth; there is no gap between

Fig. 14. *Calcinus laevimanus* (RANDALL), ×4.

fingers; the cutting margins of them with tufts of setae. The right cheliped much compressed; fingers more or less rugose, hairy on the surface with tips spoon-shaped.

Second and third legs shorter than the larger cheliped; smooth and unarmed, but only in carpus there is a spine at distal end of upper margin; dactylus and distal part of propodus with a few tufts of setae; dactylus much shorter than propodus.

Colour in life. Carapace pale blue; the proximal third of eye-stalk blue, but the distal two-thirds of an orange colour; antennule and antenna also orange. Cheliped blackish purple, except white distal parts. Dactylus and posterior half of

Fig. 15. *Calcinus laevimanus* (RANDALL).
a, Lateral view of left antennule, ×33. b, lower view of basal joints of the same, ×33. c, lateral view of basal joints of left antenna, ×33. d, lower view of left third maxilliped, ×16.

propodus of outer surface of the left cheliped of a white colour. Fingers of right cheliped reddish at the base and the tip white; merus and carpus of second and third legs yellowish brown and two dark brown lines on outer surface; propodus orange; dactylus white and marked with a yellowish brown spot on both inner and outer sides, besides them there is a cross-band of the same colour near the distal end of claw where it is black.

Colour in alcohol. Body whitish. The distal two-thirds of eye-stalk of an orange colour, but the proximal third pale red. Antennule and antenna yellowish. Chelipeds bluish brown, except white distal parts. Second and third legs light reddish brown with red long lines.

Material examined.

Nakano-shima, 1 ♀ (TK. No. 577), May 25, June 3–13, 1953 (TOKIOKA).

Takara-jima, 4 ♂♂, 7 ♀♀, 1 ovig. ♀ (TK. No. 578), May 26–June 1, 1953 (TOKIOKA).

Dimensions (in mm).

	♂	♀	ovig. ♀
c. l.	5.8	10.0	9.0
c. b.	4.0	7.5	7.5

Distribution. Indo-Pacific region from S. E. Africa to Hawaii. The northern-most locality is Seto, Prov. Kii, Japan.

12. *Calcinus gaimardi* (H. MILNE EDWARDS, 1848)

(Figs. 16–17)

Jap. name: Kuriiro-sangoyadokari

Pagurus gaimardi H. MILNE EDWARDS, p. 63–Amboina, type locality (not seen).
Calcinus gaimardi ORTMANN 1892, p. 294–Amami-Oshima.

Description. Carapace smooth, polished, well calcified. Eye-stalk much longer than anterior border of carapace, and also longer than peduncle of antennule and

Fig. 16. *Calcinus gaimardi* (H. MILNE EDWARDS), ×2.5.

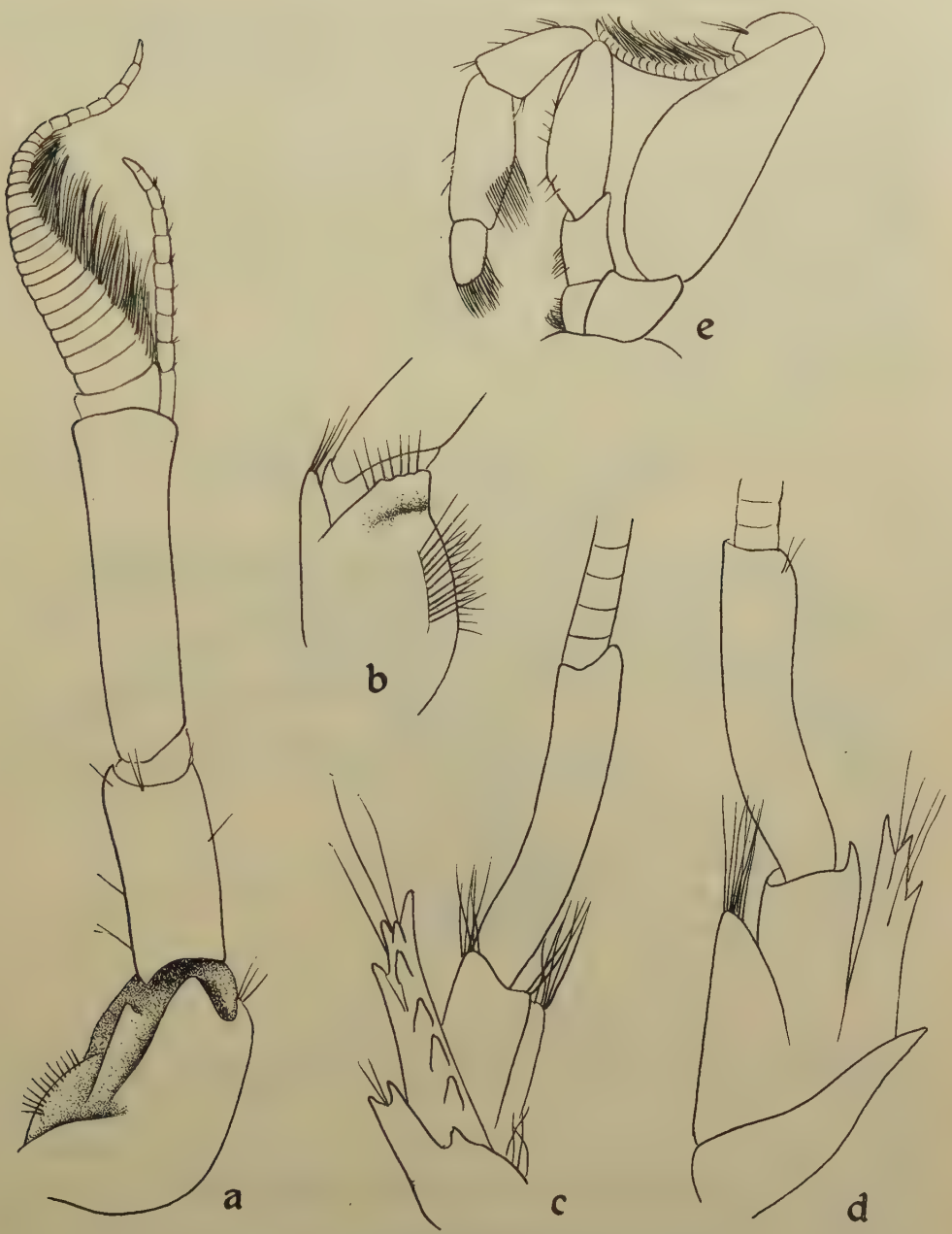


Fig. 17. *Calcinus gaimardi* (H. MILNE EDWARDS).
a, Lateral view of left antennule, ×33. b, lower view of coxopodite of the same, ×33. c, upper view of basal peduncles of left antenna, ×33. d, lateral view of the same, ×33. e, lower view of left third maxilliped, ×16.

antenna. Antennal acicle with five spinules on inner margin, but two on outer one, overreaching one-fourth of the distal end of penultimate joint of the antennal peduncle. Coxopodite of antenna with two spinules on outer distal angle, and with a spiniform tubercle on inner distal one.

Chelipeds smooth, hairless; the left cheliped larger than the right one. There is an oblique groove on upper surface of wrist; palm longer than dactylus; immovable finger with two obtuse teeth, movable finger with four ones on cutting margins; fingers with a few tufts of setae on inner margin, tips of which spoon-shaped; there is a large gap between them. Upper border of right cheliped angular, more or less hairy, serrated; merus with a spine at distal end of outer lower margin; wrist with a spine at the end of upper margin; propodus serrated on upper border in whole length; fingers somewhat rugose on anterior surface with tips spoon-shaped.

Second and third legs longer than the larger cheliped, the right one distinctly longer than the left; merus with a spinule at distal edge on outer lower margin; carpus with a spine at distal end of upper border; dactylus and propodus with tufts of hairs on posterior margin, especially third leg clothed thickly with above-mentioned hairs.

Colour in life. Carapace pale bluish; eye-stalk blue in distal half, while black in proximal half; antennule and antenna yellowish orange. Cheliped brownish purple with tips white; second and third legs red-brown with dark coloured spots in dactylus; its distal part whitish; claw black.

Colour in alcohol. Carapace white; antennule and antenna yellowish orange; eye-stalk pale red in anterior half, but brown-red in posterior half. Chelipeds dark brown-red with tips white; merus and wrist of second and third legs reddish-brown; propodus and dactylus light brown-red with red spots only in dactylus; hairs of propodus and dactylus a pale purple colour.

Material examined.

Takara-jima, 6♂♂, 2♀♀ (TK. No. 579), May 26–June 1, 1953 (TOKIOKA).

Dimensions (in mm).

	♂	♂	♂	♂	♂	♂	♀	♀
c. l.	4.0	6.0	6.5	8.0	10.0	10.5	4.5	10.8
c. b.	3.1	4.5	4.5	5.3	7.0	7.3	3.6	7.0

Distribution. Indo-Pacific area. The northern limit of this species is Seto, Prov. Kii, Japan.

13. *Calcinus terrae-reginae* HASWELL, 1882

(Figs. 18–19)

New Jap. name: Aomidori-sangoyadokari

Calcinus terrae-reginae HASWELL 1882, p. 158–Claremont Islands, Queensland Coast (type-locality).

Calcinus terrae-reginae DE MAN 1887, p. 439–Java.
Calcinus terrae-reginae DE MAN 1885, p. 226–Mergui Islands.
Calcinus latens terrae-reginae ALCOCK 1905, p. 57, pl. 5, f. 7–Maldives, Minikoy.
Calcinus terrae-reginae ESTAMPADOR 1937, p. 505–Mindoro, Philippines.
Calcinus latens var. *terrae-reginae* BUITENDIJK 1937, p. 269 Celebes, Kleine Soenda, Molukkas.

Description. Eye-stalk excluding eye exactly as long as anterior border of carapace; nearly equal to antennular peduncle of males, but a little shorter than that of females. Antennal acicle with five spinules, two of them on outer margin, the other three on inner margin, reaching beyond the proximal end of last joint of

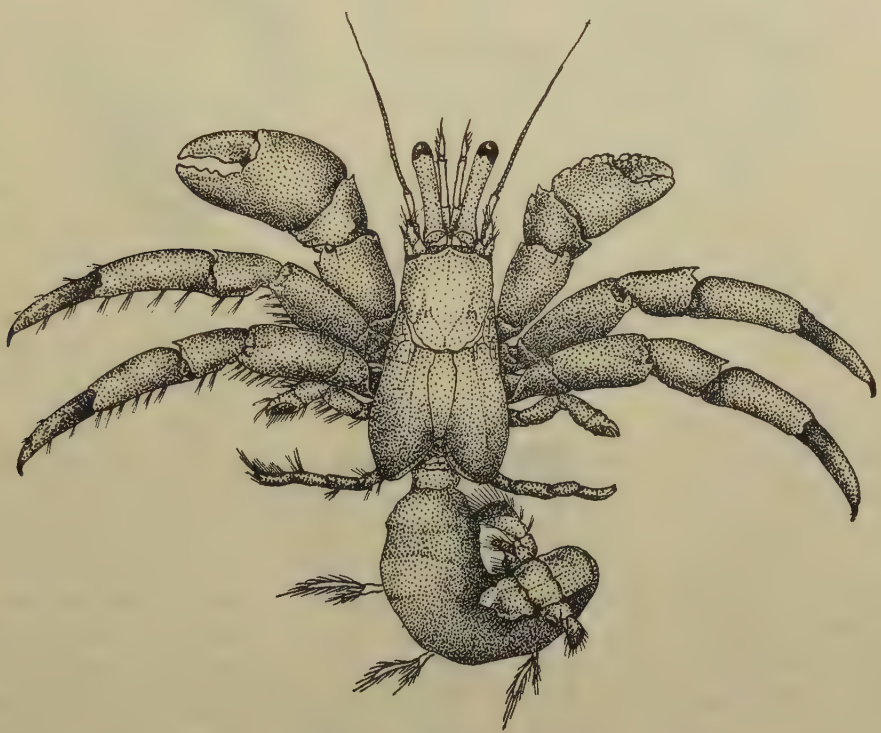


Fig. 18. *Calcinus terrae-reginae* HASWELL, ×3.5.

antennal peduncle. Ophthalmic scale overreaches the base of eye-stalk, and the tip pointed.

Cheliped smooth, the left one longer than the right. The left cheliped a little longer than ambulatory legs; wrist with an oblique groove on upper surface, which is not so deep in the allied species *C. latens*; the under surface of palm smooth, but outer surface of palm and fingers covered with granules. The right cheliped much compressed; upper border of wrist, palm and immovable finger rested by laminate teeth.

Second and third legs strongly compressed; carpus with a spine at distal end of

upper border; propodus and dactylus with tufts of bristles; the ornamentation of bristle of this species is more thickly than that of the species *C. latens*.

Colour in life. Carapace whitish, sometimes dark bluish gray; eye-stalk marked with blue in distal half, but orange in basal half; antennule and antenna orange-brown. Cheliped and legs grayish blue and olive; dactylus of second and third legs

Fig. 19. *Calcinus terrae-reginae* HASWELL.
a, Frontal region, ×16. b, lateral view of antennule, ×50. c, lower view of coxopodite of the same, ×50. d, upper view of antenna, ×50. e, lower view of left third maxilliped, ×33.

with a purplish brown cross-band at the base; propodus of them orange in proximal half. It is easily distinguished by the living coloration.

Colour in alcohol. Carapace and eye-stalk whitish. Cheliped light brownish red. The cross-bands of dactyli of second and third legs reddish. The rest of the body whitish.

Material examined.

Takara-jima, 2♂♂, 1♀ (TK. No. 580), May 25, June 3–13, 1953 (TOKIOKA).

Dimensions (in mm).

	♂	♂	♀
c. l.	7.5	5.5	3.8
c. b.	5.0	4.0	3.0

Distribution. Widely distributed in the Indo-Pacific region. Takara-jima is the northern limit of this species, and this is the first record in Japan.

14. *Calcinus latens* (RANDALL, 1839)

(Figs. 20–21)

New Jap. name: Usumurasaki-sangoyadokari

Calcinus latens STIMPSON 1858, p. 85; 1907, p. 208–Loo Choo (Okinawa-Hontō).
Calcinus latens ORTMANN 1892, p. 293–Amami-Oshima.
Calcinus latens TERAO 1913a, p. 592, f. 2, 2a–Naha, Okinawa-Hontō.

Description. Eye-stalk excluding eye as long as antennular peduncle, and distinctly longer than antennal peduncle. Antennal acicle with five to six spinules, one of them on outer margin, the others on inner one, reaching beyond the proximal end of the last joint of antennal peduncle. Ophthalmic scale with three spinules at the tip; it is easily distinguished from the allied species, *C. terrae-reginae*.

Cheliped smooth, unequal; the left one a little larger than the right. The oblique groove on outer surface of the left wrist distinct; the upper borders of palm and movable finger with granules in a line; wrist, palm and fingers furnished with fine, coarse granules. The shape and ornamentation of right cheliped are similar to those of the left one.

Second and third legs are longer than cheliped; carpus with a spine at distal end of upper border; propodus and dactylus with a few tufts of bristles.

Colour in life. Carapace pale bluish. Eye-stalk white in distal half, but its basal half dark purple. Antennule and antenna brown. Cheliped pale bluish; wrist and distal third of merus marked with a dark purplish brown cross-band. Dactylus of second and third legs marked with a dark purplish brown cross-band at the base; the rest of the surface, however, is washed with pale blue.

Colour in alcohol. Specimens have been preserved in alcohol for nine months. The basal half of eye-stalk, wrist and merus of cheliped purplish. The proximal half of dactylus of second and third legs light brown red. The rest of the body of a white colour.

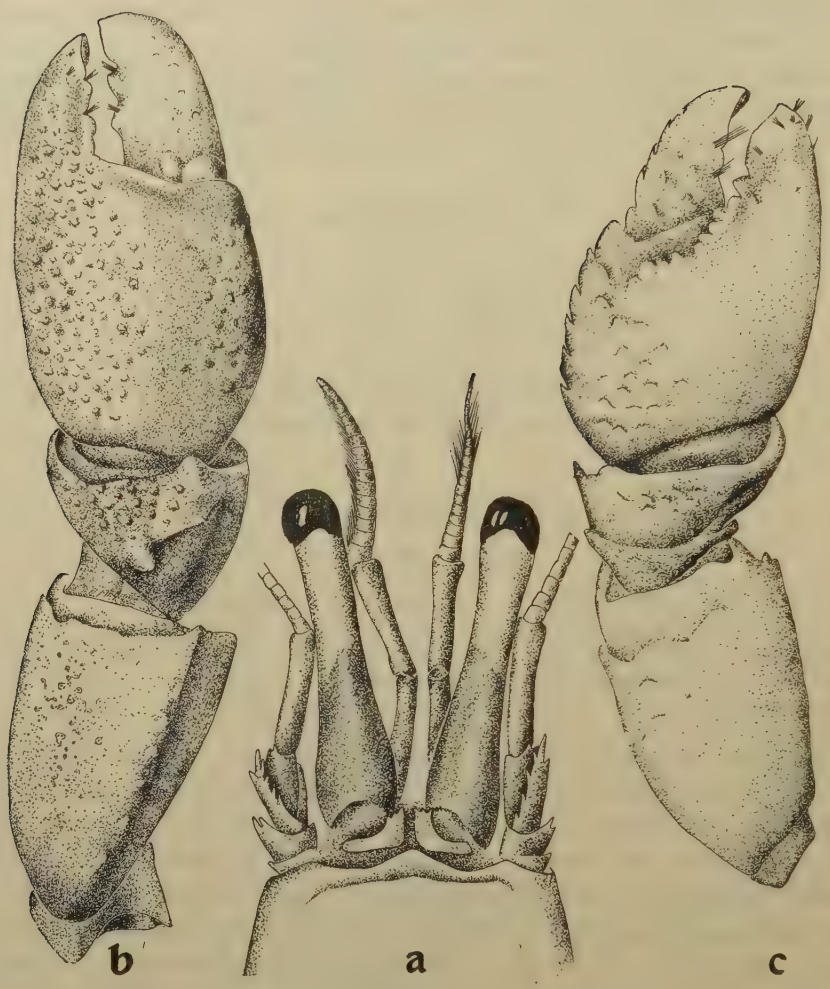


Fig. 20. *Calcinus latens* (RANDALL).
a, Frontal region, ×16. b, upper view of left cheliped, ×16. c, lower view of the same, ×16.

Material examined.

Takara-jima, 2 ♂ ♂, 1 ovig. ♀ (TK. No. 581), May 26–June 1, 1953 (TOKIOKA).

Dimensions (in mm).

	♂	♂	ovig. ♀
c. l.	6.8	5.5	5.4
c. b.	5.0	4.0	4.2

Distribution. A widely distributed Indo-Pacific species. The northern-most locality is Takara-jima.

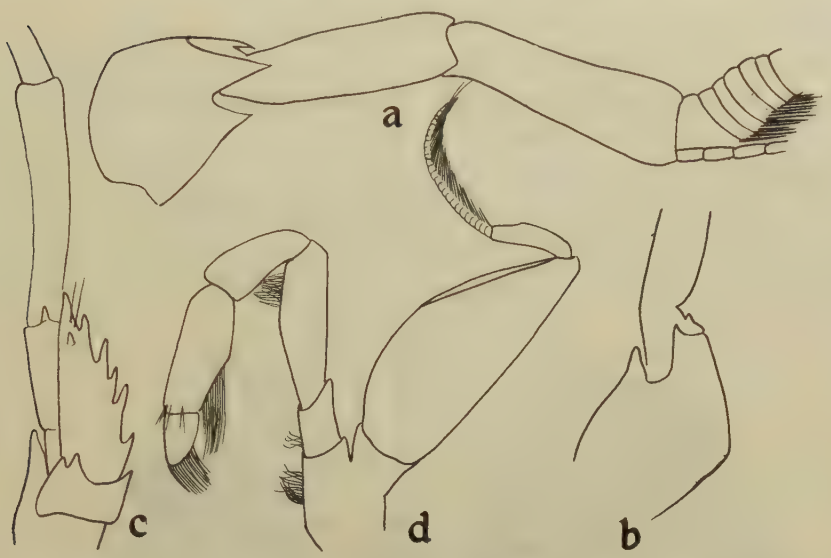


Fig. 21. *Calcinus latens* (RANDALL).
a, Lateral view of left antennule, ×40. b, lower view of coxopodite of the same, ×40. c, upper view of left antenna, ×40. d, lower view of left third maxilliped, ×25.

Family COENOBITIDAE ORTMANN, 1892

15. *Coenobita rugosus* H. MILNE EDWARDS, 1837

(Figs. 22–23)

Jap. name: Naki-okayadokari

Coenobita rugosa H. MILNE EDWARDS 1837, p. 241–Indian Ocean (type locality).
Coenobita rugosa DE HAAN 1849, p. 212–Japan.
Cenobita rugosa STIMPSON 1858, p. 70–Pacific Ocean.
Coenobita rugosa ORTMANN 1892, p. 317, pl. 12, f. 22–Amami-Oshima; Indischer Ocean, Südsee, Tahiti, Neu-Hannover.
Coenobita rugosa STIMPSON 1907, p. 199–Bonin Is.; Tahiti.
Coenobita rugosa TERAO 1912, p. 104–Bonin Is.
Coenobita rugosa TERAO 1913, p. 389–Oshima, Prov. Izu; Okinawa-Hontō; Tamsui, Formosa; Bonin Is.
Coenobita rugosus BALSS 1913, p. 69–Nagasaki; Tamsui, Takao, Formosa.
Coenobita rugosus MAKI et TSUCHIYA 1923, p. 108, pl. 9, f. 6–Shinchiku, Kelung, Formosa.
Coenobita rugosus TAKAHASHI 1934, p. 510, f. 2–Formosa, Kōtōsho (Botel Tobago I.), Kashōtō (Samasana I.).
Coenobita rugosus YAMAGUCHI 1938, p. 163–Kikai I. (28° 20′ N.; 130° E.).
Coenobita rugosa MIYAKE 1951, p. 135–Nada, Seto, Shirahama, Prov. Kii.
Cenobita purpurea STIMPSON 1858, p. 83; 1907, p. 198–Bonin Is.; "Amakirrima" (Kerama-Group, near Okinawa-Hontō).
Coenobita perlata var. *purpurea* MELIN 1939, p. 54–Port Lloyd, Bonin Is. (Futami, Ogasawara Is.).

Material examined.

Nakano-shima, May 25, June 3–13, 1953.

4♂♂ (a, b, c, d), 4♀♀ (e, f, g, h) (TK. No. 582), collected by TOKIOKA;

1♂ (i), 1♀ (j), collected by MIYAMOTO.

Takara-jima, May 26–June 1, 1953.

3♂♂ (n, o, p), 4♀♀ (q, r, s, t) (TK. No. 583, 584), collected by TOKIOKA;

2♂♂ (u, v) 1♀ (w), collected by MIYAMOTO.

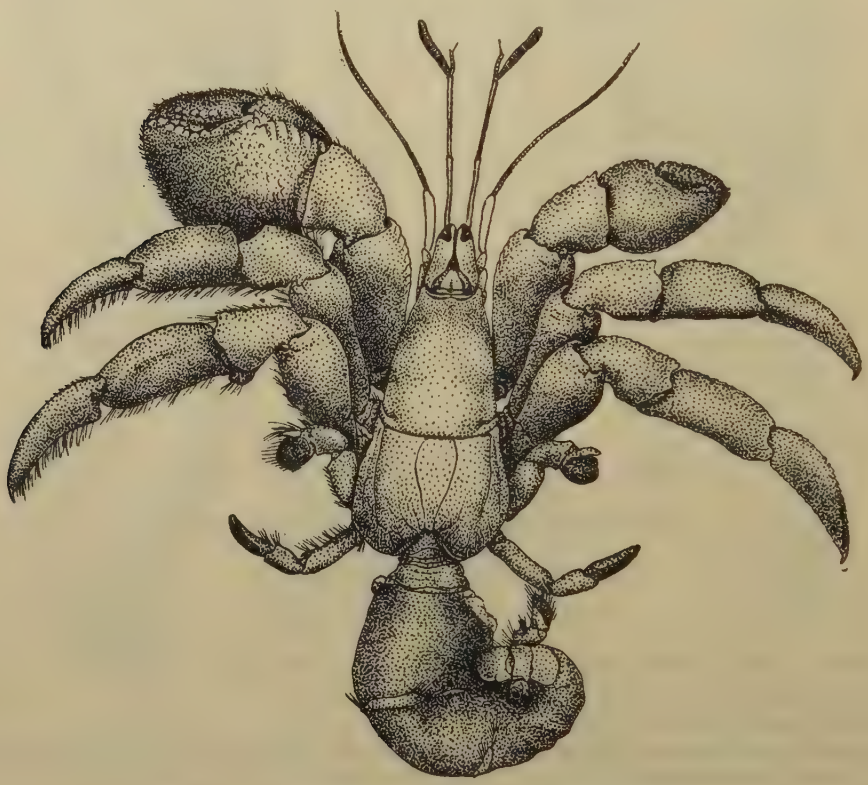


Fig. 22. *Coenobita rugosus* H. MILNE EDWARDS, ×2.

Dimensions (in mm).

Males

	k	a	i	u	n	b	c	d	p	o	v
c. l.	5.3	7.3	8.0	8.9	9.8	14.5	16.0	16.5	21.0	22.0	33.8
c. b.	5.0	5.0	5.2	5.2	6.0	10.0	11.0	11.2	13.6	14.0	19.0
r. c. p.[1)]	1.0	2.0	2.1	3.8	miss.	6.8	7.2	7.1	7.0	6.5	12.0
l. c. p.[2)]	0.8	1.2	1.8	2.0	miss.	4.1	4.3	5.0	4.3	3.6	8.0

1) right coxal process, 2) left coxal process.

Females

	l	e	f	m	q	r	s	t	g	h	j	w
c.l.	4.0	5.2	6.0	6.3	7.0	7.0	8.3	9.8	11.0	11.3	14.0	17.2
c.b.	2.8	3.5	4.0	4.0	4.0	4.3	5.0	7.1	8.0	9.2	9.0	11.0

Remarks. After closer examination, the following variations of the coxal elongation of the fifth leg of the male and coloration were observed.

In smaller individuals up to 7 mm in length of carapace, the right coxal process is almost equal to the left one as in the examples (a, k) illustrated in the Fig. 23, a,

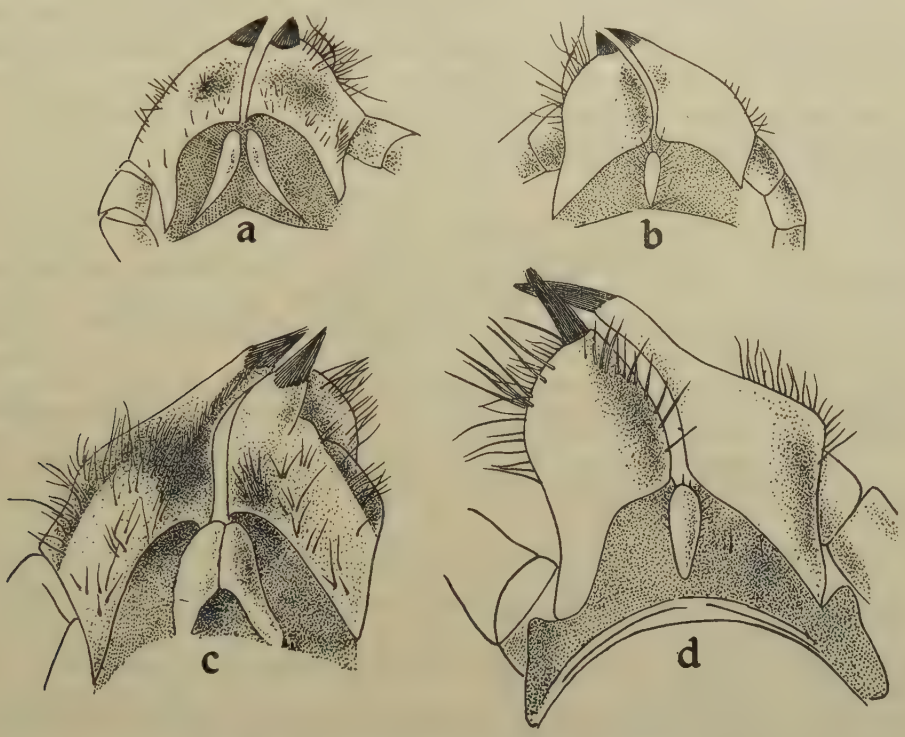


Fig. 23. *Coenobita rugosus* H. Milne Edwards.
a, Lower view of the coxal process of the specimen a, ×12. b, upper view of the same, ×12. c, lower view of the coxal process of the specimen n, ×8. d, lower view of the same, ×8.

b; in larger specimens more than 8 mm in length of carapace, the right process is distinctly longer than the left as in Fig. 23, c, d.

The following description is based upon one female of olive colour (j, 14 mm in length of carapace) from Nakano-shima. General ground-colour of dorsal face orange-yellow, the ventral face lighter. Antennule red, antenna dark brown. Carapace and legs marked with dark brown patches or spots; fingers of chelipeds, dactyli of second and third legs bluish with dark brown spots distally.

Most of all smaller specimens up to 15 mm in length of carapace have the similar colour. It has, however, nearly gone in alcohol preserved in 14 months. Legs and carapace of an olive colour with dark reddish-brown patches or spots.

In larger specimens more than 15 mm in length of carapace, legs and carapace become purplish. The living colour of a male (v, 33.8 mm in length of carapace) described below. Eye-stalk bluish purple; peduncles of antennule and antenna light blue; flagella light greenish brown. Legs and carapace of a deep purplish colour with red or red-brown spots on left cheliped.

The living colour of *C. purpurea* STIMPSON (1858) from Kerama Group "Amakirrima" seems to be similar one mentioned above. According to YAMAGUCHI (1938), general body-colour of *C. rugosus* which is pale red in the adolescent stage becomes purple or gray during the growth-period.

Distribution. The most widespread land hermit-crab in the Indo-Pacific area. The northern limit of this species is Nada, Prov. Kii, Japan.

LITERATURE

ALCOCK, A. 1905. Catalogue of the Indian Decapod Crustacea in the collection of the Indian Museum. II. Anomura, Fasc. 1, Pagurides, Calcutta. 1–197, pls. 1–16.

BALSS, H. 1913. Ostasiatische Decapoden. I. Die Galatheiden und Paguriden. Abh. K. B. Ak. Wiss. München, math.-phys. Kl., Suppl. 2 (9): 1–85, pls. 1–2.

———— 1914. *Ditto*, II. Die Natantia und Reptantia. *Ibid.* Suppl. 2 (10): 1–101, pl. 1.

BOPRADAILE, L. A. 1898. On some Crustaceans from the South Pacific. II. Macrura anomala. Proc. zool. Soc. London, 1898: 457–468, pl. 36.

———— 1906. Marine Crustaceans. XIII. The Hippidea, Thalassinidea and Scyllaridea. In: GARDINER's The fauna and Geography of the Maldive and Laccadive Archipelagoes. Cambridge. 2: 750–754, pl. 58.

BUITENDIJK, A. M. 1937. Biological results of the Snellius Expedition. IV. The Paguridea of the Snellius Expedition. Temminckia, Leiden, 2: 251–280.

DANA, J. D. 1852. Crustacea.—United States Exploring Expedition during the years 1838–1842 ·····**13**: 1–1620; 1855, pls. 1–96.

ESTAMPADOR, E. P. 1939. A check list of Philippine Crustacean Decapods. Philipp. J. Sci., Manila., **62** (4): 465–559.

FIZE, A. et R. SERÈNE 1955. Les Pagures du Vietnam. Notes Inst. Oceanogr. Nhatrang, Viet-Nam, (45): i–ix, 1–228, text-figs. 1–35, pls. 1–6.

FOREST, J. 1953. Crustacés Décapodes Marcheurs des îles de Tahiti et des Tuamotu. I. Paguridea. Bull. Mus. nat. Hist. nat., sér. 2, **25** (5): 441–450.

DE HAAN, W. 1833–1850. Crustacea. In: P. F. SIEBOLD, Fauna Japonica, Batavia. 1–244, pls. 1–55.

HASWELL, W. A. 1882. Catalogue of the Australian stalk- and sessile-eyed Crustacea, Sydney, 1–324, pls. 1–4.

HENDERSON, J. R. 1888. Report on the scientific results of the Voyage of H. M. S. Challenger, Zool. **27**. Anomura, 1–221, pls. 1–21.

MAKI, M. and H. TSUCHIYA 1923. A monograph of the Decapod Crustaceans from Formosa (in Japanese). Dep. Agric. Gov. Res. Inst. Formosa, Rep. 3: 1–215, pls. 1–24.

DE MAN, J. G. 1887. Bericht über die von Herrn Dr. J. BROCK im indischen Archipel gesammelten Decapoden und Stomatopoden. Arch. Naturgesch, Berlin, **53**: 215–600, pls. 7–22.

———— 1888. Report on the Podophthalmus Crustacea of the Mergui Archipelago. J. Linn. Soc. London, Zool., **22**: 1–312, pls. 1–19.

——————— 1902. Die von Herrn Prof. KÜKENTHAL im Indischen Archipel gesammelten Dekapoden und Stomatopoden. Abh. Senkenberg naturforsch. Ges., Frankfurt a.M., **25** (3) : 467–929, pls. 19–27.

MELIN, G. 1939. Paguriden und Galatheiden von Prof. Dr. Sixten BOCKS Expedition nach den Bonin-Inseln 1914. K. svensk. Vetensk. Ak. Handl., Stockholm, Tredje ser., **18** (2) : 1–119.

MILNE EDWARDS, H. 1836. Observations zoologiques sur les Pagures et description d'un nouveau genere de la tribu des Paguriens. Ann. Sci. nat. Zool., Paris, sér. 2, **6** : 257–288, pls. 13–14.

——————— 1837. Des Decapodes Anomoures. In : Histoire naturelle des Crustacés, comprenant l'Anatomie, la Physiologie et la Classification de ces animaux. Paris, **2** : 168–277.

MIYAKE S. 1943. Studies on the crab-shaped Anomura of Nippon and adjacent waters. J. Dep. Agric. Kyusyu Imp. Univ., Fukuoka, **7** (3) : 49–158.

——————— 1951. A check list of Anomura from Prov. Kii, Japan (in Japanese, mimeographed) Nanki-Seibutsu, **2** (3–4) : 127–140.

NAKAZAWA, K. 1927. Anomura. In : Nippon Dôbutsu Zukan (Illustrated Encyclopedia of the fauna of Japan), Tokyo (in Japanese). 1035–1051, figs. 1993–2025.

NAKAZAWA, K. and S. MIYAKE 1947. *Ditto*, 1st revised ed. 731–750, figs. 2115–2171.

——————— 1949. *Ditto*, 2nd revised ed. 731–752, figs. 2115–2177.

NOBILI, G. 1906. Faune Carcinogique de la Mer Rouge. Decapodes et Stomatopodes. Ann. Sci. nat. Zool., Paris, sér. 9, **4** : 1–347, pls. 1–11.

ORTMANN, A. E. 1892. Die Decapoden-Krebse des Strassburger Museums. IV. Die Abtheilungen Galatheidea und Paguridea. Zool. Jb. Syst., Jena, **6** : 241–326, pls. 11–12.

PESTA, O. 1914. Crustacea. II. Decapoda (mit Ausschluß der Brachyura) und Stomatopoda aus Samoa. Denkschr. Ak. Wiss. Wien, math.-naturw. Kl., **89** : 673–683.

SHIINO, S. M. 1933. Bopyrids from Tanabe Bay. Mem. Coll. Sci. Kyoto Imp. Univ., ser. B, **8** (3) : 249–300.

STIMPSON, W. 1858. Prodromus descriptionis animalium evertebratorum, quae in Expeditione ad Oceanum Pacificum Septentrionalem. VII. Crustacea Anomoura. Proc. Ac. nat. Sci., Philadelphia, 63–90.

——————— 1907. Report on the Crustacea (Brachyura and Anomura) collected by the North Pacific Exploring Expedition, 1853–1856. Smithson. Miscell. Coll., Washington, **49** : 1–240, pls. 1–26.

TAKAHASHI, S. 1934. On the land-hermits (Coenobitidae) in Formosa (in Japanese). Trans. nat. Hist. Soc. Formosa, **24** (135) : 506–507.

TERAO, A. 1913. A catalogue of hermit-crabs found in Japan (Paguridae excluding Lithodidae), with description of four new species. Annot. Zool. Jap., Tokyo, **8** : 355–391.

——————— 1913–1914. Hermit-crabs of Japan (in Japanese). Zool. Mag., Tokyo. **25** : 591–594 ; **26** : 109–110, 181–182.

YAMAGUCHI, S. 1938. Spawning and development of *Coenobita rugosus* (in Japanese with English résumé). Bult. Sci. Fakult. Terkurt. Kjušu Imp. Univ. Hukuoka, **8** (2) : 163–177, pl. 2.

INVERTEBRATE FAUNA OF THE INTERTIDAL ZONE OF THE TOKARA ISLANDS

XIV. STONY CORALS AND HYDROCORALS[1)2)]

Huzio UTINOMI
Seto Marine Biological Laboratory, Sirahama

With Plates XXXI–XXXII

The weak development of living reef corals along the raised reefs in the Tokara Islands, where is approximately the northernmost limit of real coral reefs (30°N. Lat.), has been noted by Tokioka (1953) and Baba (1954), who gave a brief sketch of the reefs and the inhabitants living there with many excellent photographs. As they noted, living corals usually grow only at crevices and holes which are found here and there on the raised reef covered by purplish Melobesiae, or at the reef margin under low tide level. So there can be seen weakly developed coral reef, particularly at Takarazima. Dr. Tokioka, in describing the outline of the shore and its life, recognized the occurrence of only 9 species of the living corals.

The present paper presents the results of a re-examination of Dr. Tokioka's collection, all deposited in the collections of the Seto Marine Biological Laboratory, and a few additional materials collected by Dr. Baba and Mr. Hori during the scientific survey which are in the collections of the Osaka Municipal Museum of Natural History.

As a result of this work, 15 species belonging to 10 genera, including one species of hydrocorals, were identified. This number is far less than those species previously recorded from Amami-ôsima and adjacent islets including Tokara Islands, a total of 63 species being now known from the area (Yabe & Sugiyama, 1935a, b; Sugiyama, 1937, p. 50). The list presented here, though small in number of species, is of interest since it records most of the common species growing so far southward, but unknown from this area. This new distributional records aid in the delimitation of the geographical range of many previously described species. Although the coral collection in this area and the environs is still meagre, the results obtained indicate the need of much more extensive exploration in all islets of the Ryukyu Islands from south to north.

1) Scientific Survey of the Tokara Islands, Report No. 31.
2) Contributions from the Seto Marine Biological Laboratory, No. 283.

In the present paper the systematic arrangement of the species is followed VAUGHAN and WELLS' system (1943). Abbreviations used in the text are as follows:

Tokara Collection in the Seto Marine Biological Laboratory.....TK. No. —

Osaka Municipal Museum of Natural History.....O.M.M.

I wish to express my appreciation at this time to Dr. Takasi TOKIOKA of our Laboratory and Mr. Yoshitaka TSUTSUI, Director of the Osaka Munici al Museum of Natural History and leader of the Scientific Survey of the Tokara Islands in 1953, for the opportunity to study on the coral collection. Special thanks are also due to Dr. Kikutaro BABA and Mr. Osamu TUZIMOTO, other members of the Scientific Survey, for the free use of photographs taken at the field.

SCLERACTINIA

Family Seriatoporidae M. EDWARDS & HAIME

1. *Pocillopora damicornis* (LINNÉ)

Pocillopora damicornis HOFFMEISTER, 1925, p. 15, pl. 1, fig. 1 (synonymy); YABE, SUGIYAMA & EGUCHI, 1936, p. 12, pl. 4, figs. 3–5.

Material examined. A complete specimen (O.M.M.), K. BABA coll. Takarazima. A fragment (TK. No. 586), T. TOKIOKA coll. Takarazima.

Distribution. East Indian and tropical West-Pacific northward to Kusimoto, middle Honsyu.

2. *Pocillopora verrucosa* (ELLIS & SOLANDER)

Pocillopora verrucosa VAUGHAN, 1918, p. 77, pl. 23, figs. 1–2a; YABE, SUGIYAMA & EGUCHI, 1936, p. 14, pl. 3, figs. 3–4.

Material examined. Three fragments (TK. No. 585), T. TOKIOKA coll. Takarazima.

Distribution. East Indian and tropical West-Pacific northward to Kita-Daitôzima, SE of Ryukyu Islands.

Family Acroporidae VERRILL

3. *Acropora formosa* (DANA)

(Pl. XXXII, Fig. 3)

Acropora formosa HOFFMEISTER, 1925, p. 55, pl. 8, figs. 1–3 (synonymy); FAUSTINO, 1927, p. 259, pl. 84, figs. 1–4; WELLS, 1950, p. 35.

Acropora gracilis FAUSTINO, 1927, p. 257.

Material examined. Two specimens (O.M.M.), M. HORI coll. Takarazima.

Both specimens are small, shrubby colonies with slender, much divided branches,

about 7–11 cm across and 9 cm in height. The branches are rather slender, mostly not over 1 cm in diameter and several short branchlets with a few tubular corallites occur near the branch-tips. The axial corallites are 2 mm in diameter, 1 to 2 mm exsert. Many of the radial corallites are tubo-nariform, their tips being truncated obliquely and 2 mm long. Other smaller corallites between them are immersed. In these respects the specimens are very close to "*gracilis*" form.

Distribution. East Indian and tropical West-Pacific northward to Amami-ôsima.

4. *Acropora abrotanoides* (Lamarck)

Madrepora abrotanoides Brook, 1893, p. 56.
Acropora abrotanoides Vaughan, 1918, p. 166, pl. 68, figs. 1–2.

Material examined. Four fragments (TK. No. 587), T. Tokioka coll. Nakanosima. Seven fragments (TK. No. 588), T. Tokioka coll. Takarazima.

Of these fragments, one somewhat complete specimen corresponds very closely to Vaughan's figured specimen from Murray Island in growth-form and in the peculiar arrangement of large radial corallites; some of them are tubular like the axial ones, others immersed, subimmersed or half-tubular. The stem is very thick, 2 cm in diameter, broadly expanded up to 3.5 cm at base, and only 6 cm in total height. Axial corallites are large, about 3 to 3.5 mm in diameter and 1 to 1.5 mm exsert; aperture about 1 mm in diameter or more.

Distribution. Tahiti, Great Barrier Reef, Singapore, Taiwan, Botel Tobago, Sakisima Islands (southernmost of Ryukyus).

5. *Acropora pectinata* (Brook)

(Pl. XXXII, Figs. 4, 5)

Madrepora pectinata Brook, 1893, p. 95, pl. 27, figs. D, E.
Acropora (*Polystachis*) *pectinata* Vaughan, 1918, p. 172, pl. 71, figs. 1–2.

Material examined. A marginal fragment (TK. No. 590), T. Tokioka coll. Takarazima.

The specimen is complanate, with flattened under surface forming a loose reticulation. Branchlets on the upper surface are crowded, usually arranged in groups of 2 to 4 along the axis of each branch which is extended horizontally, coalescent to one another, and flattened below. They are directed upward, except near the margin where they are horizontal and shorter; apices about 5 to 10 mm apart. Their average height is 2–3 cm and diameter 6 mm. Axial corallites are tubular, about 2 mm in diameter, with rather large aperture provided with 12 septa. Radial corallites are short, spreading, round-labellate, and 1–1.5 mm in diameter; walls porous, distinctly costulate, down to echinulate. In the marginal area of corallum, axial corallites are more prominent, about 2 mm exsert. On the under surface, all corallites are immersed,

with small aperture except on the marginal area where they are somewhat nariform.

Distribution. Great Barrier Reef, Torres Strait, Ogasawara Islands.

6. *Acropora* cf. *hebes* (DANA)

(Pl. XXXII, Fig. 6)

Acropora hebes VAUGHAN, 1918, p. 174, pl. 73, figs. 2–2a; pl. 74, figs. 1–2b; HOFFMEISTER, 1925, p. 57, pl. 9, figs. 3a–3b.

Material examined. A fragment (O.M.M.), M. HORI coll. Takarazima.

A fragment, consisting of three branches, may probably agree with this species figured by VAUGHAN and HOFFMEISTER. Longest one of the branches is terete, scarcely tapering, 8 cm long and 1 cm in diameter all throughout. Radial corallites are much crowded, subequal, labellate, 1.5–2 mm in average diameter. Another branch is proliferous near the tip, bearing some labellate twig-buds.

Distribution. Fiji Is., Samoa, Great Barrier Reef, Cocos-Keeling Atoll, Marshall Is., Taiwan northward to Amami-ôsima.

7. *Acropora gemmifera** (BROOK)

(Pl. XXXI, Fig. 1)

Madrepora gemmifera BROOK, 1893, p. 142, pl. 21.
Acropora (*Tylophora*) *gemmifera* VAUGHAN, 1918, p. 177, pl. 77, figs. 1–3a.

Material examined. Two fragments, apparently belonging to a single colony (TK. No. 589), T. TOKIOKA coll. Takarazima.

Material collected by Dr. TOKIOKA shows a stunted face of the corallum. It is spreading-corymbose, 7 cm high and 12 cm across from the center of a broad base. Upright branchlets 1–2 cm thick are all unusually short, truncated at tips, showing a repair growth. Axial corallite is however present in the center of each truncated tip, although small and immersed. Such flat-topped formation may be due to the effect of long-term exposure in the levelling of the upper surfaces of colonies by stopping further upward growth.

Dr. BABA's good photograph of a living colony under water gives a better conception of the typical growth-form of this species.

Distribution. Fiji Is., Great Barrier Reef, Torres Strait, Arafura Sea, Pescadores Is., Botel Tobago northward to Sakisima Is. (southernmost of Ryukyus).

Family Agariciidae GRAY

8. *Coeloseris mayeri* VAUGHAN

*) Written as *A. scherzeriana* (BRÜGGEMANN) in TOKIOKA's paper.

Coeloseris mayeri VAUGHAN, 1918, p. 139, pl. 58, figs. 1–3a ; YABE, SUGIYAMA & EGUCHI, 1936, p. 63, pl. 18, figs. 7–8 ; pl. 38, figs. 2–4.

Material examined. One encrusting specimen (TK. No. 591), T. TOKIOKA coll. Takarazima.

Distribution. Bay of Bengal, Batavia, Murray Island, Philippines, Palau, Taiwan and Yonakunizima.

Family Thamnasteriidae VAUGHAN & WELLS

9. *Psammocora contigua* (ESPER)

Psammocora contigua YABE, SUGIYAMA & EGUCHI, 1936, p. 59, pl. 44, figs. 5, 6, 8 ; pl. 45. figs. 2, 3, 6 (synonymy).

Material examined. Two fragments (TK. No. 592), T. TOKIOKA coll. Takarazima.

The corallum is arborescent with knotty heads, but heavily coalesced downward, showing a rough-water form in manner of growth. Small calyces with indistinct columella are arranged in rows in the valleys on the branches.

Distribution. East Indian and tropical West-Pacific, southward to the Tropic of Capricorn and northward to Kita-Daitôzima.

Family Fungiidae DANA

10. *Fungia* sp. (cf. *concinna* VERRILL)

Fungia concinna YABE & SUGIYAMA, 1941, p. 79, pl. 73, figs. 1–1c ; pl. 74, fig. 3 ; pl. 75, figs. 1–2d (synonymy).

Material examined. One beach-worn specimen (O.M.M.), K. BABA coll. Takarazima.

A single much-worn corallum, measuring 10×8.9 cm across and 3 cm high, seems to be closer to *F. concinna* which is common in the Ryukyu Islands than to any other species. Costae on the upper surface are only distinct and regularly alternate in size; base finely costate from the center to the margin.

Distribution. Zanzibar to Samoa, northward to Amami-ôsima.

Family Poritidae GRAY

11. *Porites lutea* M. EDWARDS & HAIME

Porites lutea var. *haddoni* HOFFMEISTER, 1925, p. 75, pl. 21, fig. 3 (synonymy).
Porites haddoni CROSSLAND, 1952, p. 241 (synonymy).

Material examined. One specimen (TK. No. 593), T. TOKIOKA coll. Takarazima.

The specimen is irregularly nodular, encrusting on dead corals, 9×6.5 cm in

extent. According to the key given by VAUGHAN (1918, p. 190), the specimen seems agree with his *haddoni* in the shallow calyces surrounded by thin, delicately spinulose walls. Average diameter of calyces is about 1 mm. Septa 12 in number, rather thick. Palar ring consists of 5 or 6 pali, usually more prominent than the septal trabecular ring pillars; they are tall and densely granulate. Columella deep down, narrower than pali.

Distribution. Great Barrier Reef, Fiji Is., Samoa, Solomon and Palau Islands. Also recorded from Sakisima Islands of Ryukyus and from the coast of Sikoku, Japan.

Family Faviidae GREGORY

12. *Favites aspera* (VERRILL)

(Pl. XXXI, Fig. 2)

Goniastrea aspera FAUSTINO, 1927, p. 141, pl. 33, figs. 1–2; YABE, SUGIYAMA & EGUCHI, 1936, p. 35, pl. 24, fig. 3.
Favites aspera CROSSLAND, 1952, p. 132, pl. 5, figs. 1–2.

Material examined. One specimen (TK. No. 594), T. TOKIOKA coll. Takarazima. One specimen (lost, not available at present), T. TOKIOKA coll. Nakanosima.

One specimen (O.M.M.), K. BABA coll. Takarazima.

A specimen (TK. No. 594) bears a number of pits which have probably been infested by the Hapalocarcinid crab, *Cryptochirus coralliodytes* HELLER.

According to Dr. TOKIOKA, *Favites aspera* is the most abundant among reef corals near the reef margin, both in Takarazima and Nakanosima, commonly mingled with soft zoantharians and alcyonarians which are called "naba" by natives.

Distribution. Philippines, Palau, Taiwan, Ryukyu Islands northward to Udo, SE coast of Kyusyu.

Family Caryophylliidae GRAY

13. *Caryophyllia* cf. *scobinosa* ALCOCK

Caryophyllia scobinosa ALCOCK, 1902, p. 8, pl. 1, figs. 2–2a; YABE & EGUCHI, 1942, p. 119, pl. 10, figs. 4–5.

Material examined. Four beach-worn specimens (TK. No. 595), T. TOKIOKA coll. Takarazima.

The specimens are all denuded on surface, so that exact identification may be hardly possible. The largest one is 30 mm long and 8 mm in diameter at base. Corallum free, lacking calicular part, somewhat curved cylindro-conical. Principal septa are 12, though bearing 31 in all, denticulate on surface. Costae straight, distinct throughout except at base. Columella small, twisted.

Distribution. East Indies, Philippines, Southern Japan northward to Inubô-zaki.

Family Dendrophylliidae Gray

14. *Balanophyllia fistula* Alcock

Balanophyllia fistula Alcock, 1902, p. 42, pl. 5, figs. 36–36a; Yabe & Eguchi, 1941, p. 141, pl. 12, figs. 14–16 (synonymy).

Material examined. Three beach-worn specimens (TK. No. 596), T. Tokioka coll. Nakanosima.

The largest one, 25 mm long, subcylindrical, gradually tapering toward the pointed base, and bears two small buds perpendicularly fastened to the parent corallite. On outer surface it bears well-developed costae but lacks epitheca.

Distribution. Red Sea, East Indies, Philippines and Japan northward to Inubô-zaki on the Pacific side and to Sado Is. in the Japan Sea side.

STYLASTERINA

Family Stylasteridae Gray

15. *Distichopora violacea* (Pallas)

Distichopora violacea Hickson, 1892, p. 501, pls. 18–19; Boschma, 1953, p. 172 (distribution).

Material examined. Numerous fragments (TK. Nos. 598, 599), T. Tokioka coll. Takarazima.

Three specimens (TK. No. 600), T. Tokioka coll. Nakanosima.

The specimens, young in all, agree exactly with Hickson's coloured figures of *Distichopora violacea* drawn from a spirit specimen from Murray Island. The specimens here examined are all dried and bright or dark purple, or rose in colour. Larger unbroken colony reaches 17 mm in height and 25 mm wide. But, in most of them clusters of gastropores, about 0.3 mm across, are visible on the flat surface of the larger stems and branches.

Distribution. East Indies, Torres Strait, Great Barrier Reef, New Hebrides, Tuamotu Is., Tahiti and Jaluit Is. Up to now unknown to occur in Japanese waters.

REFERENCES

Alcock, A. 1902. Report on the deep-sea Madreporaria of the Siboga Expedition. Siboga-Expeditie, Monog. XVIa.

Baba, K. 1954. Coral reef animals. In: Tokara Islands, compiled by Y. Tsutsui (Asahi Syasin Book 2), pp. 44–55. (In Japanese.)

Boschma, H. 1953. The Stylasterina of the Pacific. Zool. Meded., vol. 32, no. 16.

Brock, G. 1893. The genus *Madrepora*. Cat. Madrep. Corals in the Brit. Mus. (Nat. Hist.), vol. 1.

Crossland, C. 1952. Madreporaria, Hydrocorallinae, Heliopora and Tubipora. Great Barr. Reef Exped. Sci. Rep., vol. 6, no. 3.

FAUSTINO, L. A. 1927. Recent Madreporaria of the Philippine Islands. Monogr. Bur. Sci. Manila, 22.

HICKSON, S. J. 1892. Notes on a small collection of Hydrocorallinae. Scient. Proc. Royal Dublin Soc., N.S., vol. 7, pt. 5.

HOFFMEISTER, J. E. 1925. Some corals from American Samoa and the Fiji Islands. Pap. Dept. Marine Biol. Carnegie Inst. Wash., vol. 22.

KAWAGUTI, S. 1953. Coral fauna of the Islands of Botel Tobago, Formosa with a list of corals from the Formosan waters. Biol. Journ. Okayama Univ., vol. 1, no. 3.

SUGIYAMA, T. 1937. On the Recent reef corals occurring in the coast of Japan. Contr. Inst. Geol. Paleont. Tôhoku Univ., No. 26. (In Japanese.)

TOKIOKA, T. 1953. Invertebrate fauna of the intertidal zone of the Tokara Islands, I. Introductory notes, with the outline of the shore and the fauna. Publ. Seto Mar. Biol. Lab., vol. 3, no. 2.

VAUGHAN, T. W. 1918. Some shoal-water corals from Murray Island (Australia), Cocos-Keeling Islands, and Fanning Island. Pap. Dept. Marine Biol. Carnegie Inst. Wash., vol. 9.

——— & WELLS, J. W. 1943. Revision of the suborders, families, and genera of the Scleractinia. Geol. Soc. America, Spec. Pap., No. 44.

WELLS, J. W. 1950. Reef corals from the Cocos-Keeling Atoll. Bull. Raffles Mus., Singapore, No. 22.

YABE, H. & EGUCHI, M. 1942. Fossil and Recent simple corals from Japan. Sci. Rep. Tôhoku Imp. Univ., 2nd Ser. (Geol.), vol. 22, no. 2.

——— & SUGIYAMA, T. 1935a. Geological and geographical distribution of reef-corals in Japan. Journ. Paleont., vol. 9, no. 3.

——— & ——— 1935b. Revised lists of the reef corals from the Japanese Seas and of the fossil reef corals of the raised reefs and the Ryûkyû limestone of Japan. Journ. Geol. Soc. Japan, vol. 42, no. 502.

——— & ——— 1941. Recent reef-building corals from Japan and the South Sea Islands under the Japanese mandate. II. Sci. Rep. Tôhoku Imp. Univ., 2nd Ser. (Geol.), Spec. vol. 2.

———, ——— & EGUCHI, M. 1936. *Ditto.* I. *Ibid.* Spec. vol. 1.

EXPLANATION OF PLATES XXXI–XXXII

PLATE XXXI

Fig. 1. *Acropora gemmifera* (BROOK), under water. Photo: K. BABA.

Fig. 2. Colonies of *Favites aspera* (VERRILL), most commonly found on the reef of Takarazima, exposed at low tide. An *Acropora* colony (probably *A. formosa*) is seen in the center. Photo: O. TUZIMOTO.

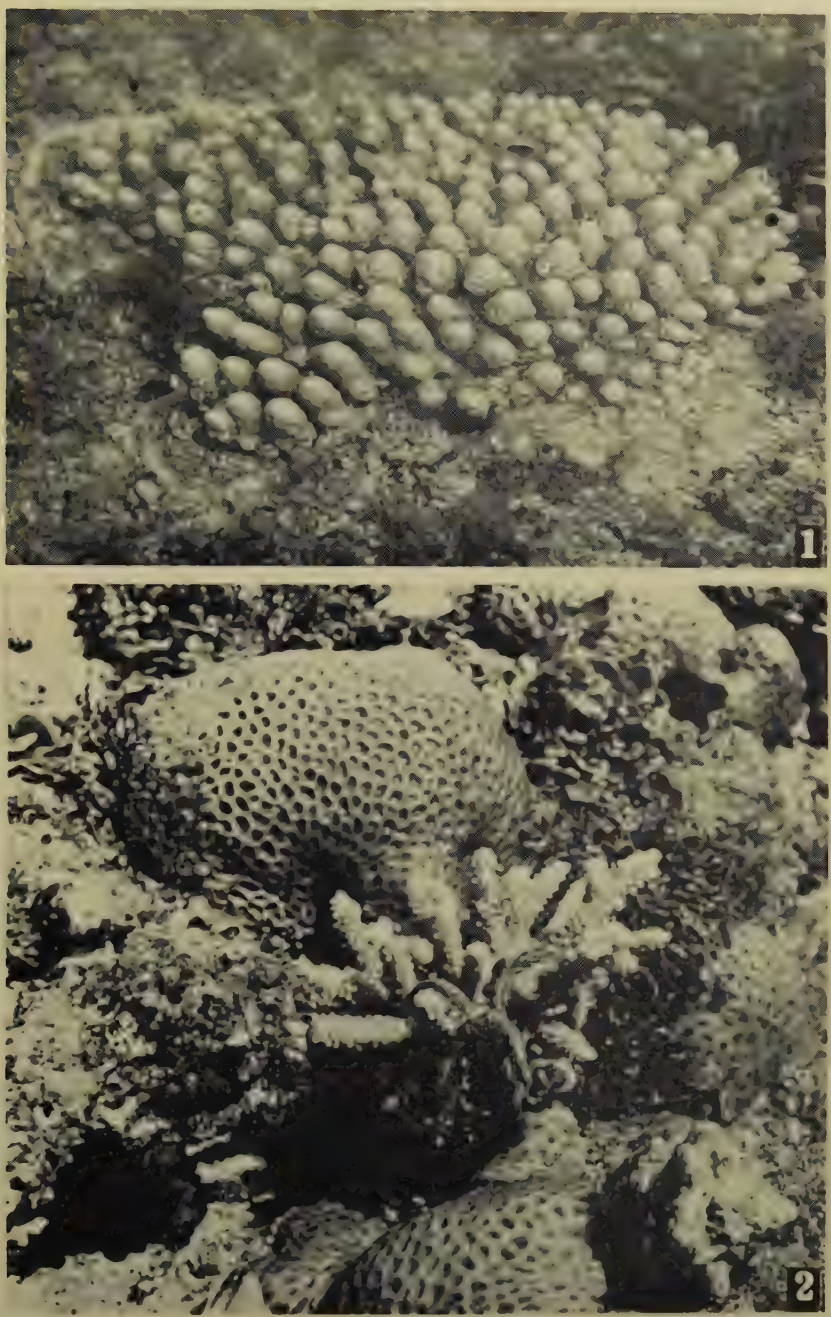
PLATE XXXII

Fig. 3. Specimen of *Acropora formosa* (DANA). ×2/3.

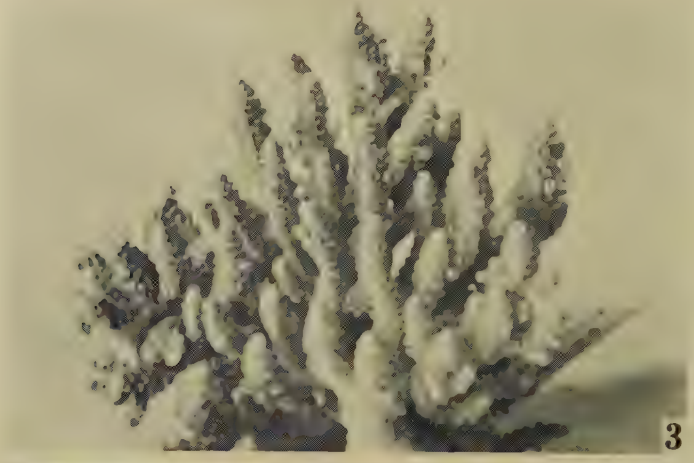
Fig. 4. A part of specimen of *Acropora pectinata* (BROOK), upper surface. Natural size.

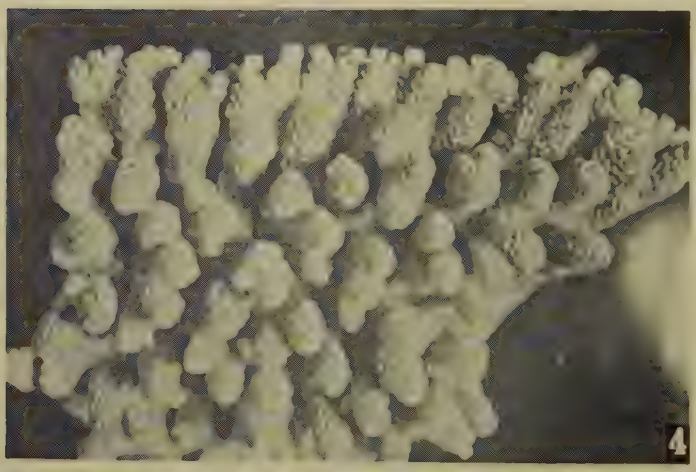
Fig. 5. *Acropora pectinata* (BROOK), three axial corallites. ×7.

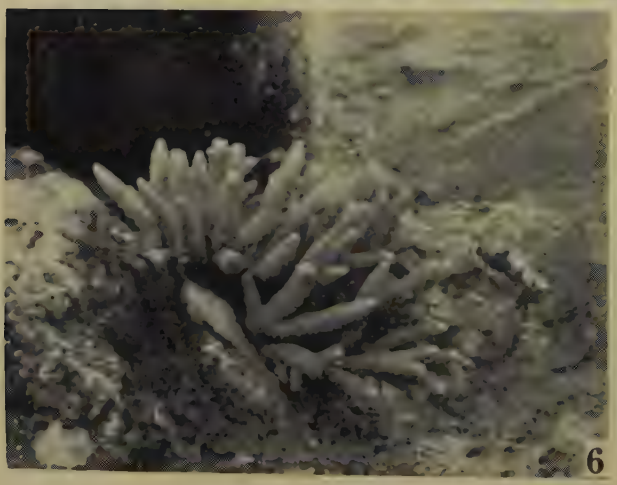
Fig. 6. *Acropora* cf. *hebes* (DANA), exposed at low tide. Photo: O. TUZIMOTO.



H. UTINOMI: INVERTEBRATE FAUNA OF THE TOKARA ISLANDS, XIV.







H. UTINOMI: INVERTEBRATE FAUNA OF THE TOKARA ISLANDS, XIV.

THE DAILY ACTIVITY RHYTHMS OF THE HOLOTHURIANS IN THE CORAL REEF OF PALAO ISLANDS[1)]

Toshihiko YAMANOUCHI
Formerly Lecturer of Zoology at Kyoto University

With 7 Tables and 3 Text-figures

CONTENTS

Page
I. Introductory Remarks 347
II. Daily Rhythms of Feeding Activities 347
III. Respiratory Rhythms 352
IV. Change of Muscle Tonus According to the State of Activity 355
V. Reversal of Daily Activity Rhythm under Experimental Conditions 357
VI. General Considerations 359
VII. Summary 360
Appendix. On the Pearl Fishes in the Palao Islands 361
Literature Cited 362

I. Introductory Remarks

The author has visited Palao Islands twice, from January to July in 1937 and from July to September in 1940, for the study of holothurian ecology. The investigations were performed at the Palao Tropical Biological Station, which has been closed since World War II. The reports of the study were published in 1938, 1939, 1941 and 1955. Some interesting facts hitherto unpublished and an interpretation of these are reported in the present article. The author believes that these will add some contributions to the ecology and physiology of holothurians.

II. Daily Rhythms of Feeding Activities

From the observations, carried out in 1937, on the behavior of holothurians in the coral reef of Palao Islands, the holothurians were classified into the following two groups according to their feeding habits (Yamanouchi 1939, p. 634).

1) Contributions from the Seto Marine Biological Laboratory, No. 284.

The A-group takes food uninterruptedly day and night, and always stays on the sandy flat (*Holothuria atra, H. edulis* and *H. flavomaculata*).

The B-group gives up feeding at least in one-third of the day (*Holothuria bivittata, H. vitiensis, H. scabra, H. lecanora* (JAEGER) var.,[1] *Stichopus variegatus* and *St. chloronotus*). Among them *H. bivittata, H. vitiensis* and *H. scabra* are buried in the sand while fasting time from before dawn to the noon or up to the evening, whereas *Stichopus chloronotus* hides itself under corals instead of burrowing in the sand while fasting.

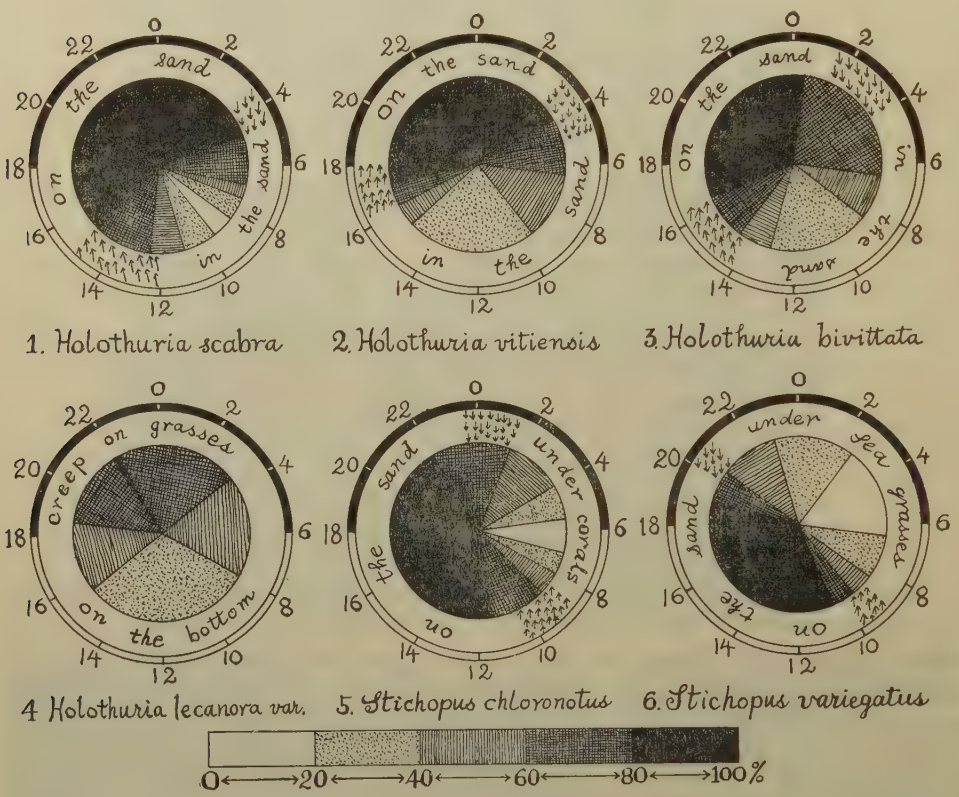


Fig. 1. The daily change in the amount of gut content, expressed in the percentage degree of fullness, in 6 holothurians inhabiting the coral reef of Palao Islands. The arrows indicate the times at which the holothurians had changed their activity grounds.

The behavior of *Stichopus variegatus* while fasting was finally made clear in the following investigation in 1940. During the fast, this species hides itself under sea grasses growing dottedly on the sandy flat (YAMANOUCHI 1941, p. 138).

The daily rhythms of feeding activity of these 6 species belonging to the B-group and its behavior are drawn schematically in Fig. 1. From this figures one sees that

1) Called by the native as "Akarumurm" (YAMANOUCHI 1939, p. 605).

4 species belonging to the Genus *Holothuria* begin actively to feed (↑) in the afternoon from the midday to the evening respectively following essentially the sun set (Fig. 1, *1–4*), whereas two species belonging to the Genus *Stichopus* commence their feeding activity (↑) in accord with the increase of sun light nearly about 5–6 hours earlier than the *Holothuria* species (Fig. 1, *5–6*).

In both groups the rhythm of external light seems to be surely the factor controlling the behavior rhythm of holothurians, and the apparent discrepancy of behavior from the external rhythm in each species should come from its intrinsic autonomous rhythm. The daily rhythms of behavior in holothurians above stated remind us of higher animals including the human being. Whether the fast period or the inactive state of six holothurian species represented in Fig. 1 corresponds to the sleeping hours of higher animals requires detailed analysis of holothurian behaviors. In the next two chapters this point will be specially considered.

In the lowest inactive state, the percentage gut contents of holothurians were as follows (given in brackets, cited from YAMANOUCHI 1939, pp. 620–623) : *Holothuria scabra* (14%), *H. vitiensis* (30%), *H. bivittata* (35%), *H. lecanora* var. (30%), *Stichopus variegatus* (5%) and *St. chloronotus* (10%). When and just after the animals moved into the sand or hid themselves under shelters, the feeding activity would not cease in all animals. Similar circumstances had been observed at the awaking state from resting. In some individuals, though not in all, feeding activity had been started considerably earlier than the actual time of coming out of the sand or from shelters (Table 1).

Table 1. Number of animals given according to the degree of fullness of their alimentary canal in different states of *Holothuria vitiensis*. 9–10/VIII, 1940.

State of animal	Just emerging from the sand	Having emerged from the sand	On the sand	Just burrowing into the sand	In the sand
Time	17.30	17–18	22	4	10
Degree of fullness					
100%	1	7	1	3	0
90	1	3	1	3	0
80	1	3	2	5	0
70	0	4	0	3	0
60	1	3	0	1	0
50	1	1	0	1	0
40	3	0	0	1	1
30	0	1	0	1	3
20	0	1	0	0	1
10	1	0	0	1	1
0	0	1	0	1	14
Total	9	24	4	20	20
Average content	57%	74%	88%	69%	8%

In *Holothuria vitiensis*, the amount of gut content of the burrowed animals was under 40% (0–40%, in average 8%) (Table 1), whereas at the exact moment of coming out of the sand or at the moment of burrowing into the sand, the amount of gut content fluctuated from 0 to 100% with wide individual variations. In *Holothuria bivittata* and *H. scabra* the circumstances were similar (Table 2). In higher animals food taking activity is entirely given up during sleep.

Table 2. Relation between the amount of gut content and the state of animals. The gut content is given in the percentage degree of fullness. The number in brackets denotes number of specimens observed.

State of animal	Just burrowing into the sand		In the sand		Just crawling out of sand		Within 1 hour after crawling out of sand		On the sand	
Animals	Time	Average gut cont.	Time	Average gut cont.	Time	Average gut cont.	Time	Average gut cont.	Time	Average gut cont.
Holothuria vitiensis	4	69%(20)	10	8%(20)	17,30	57%(9)	15–18	74%(24)	22	88%(4)
H. bivittata	1,30	83%(10)	11	32%(14)	19	44%(13)	–	–	–	–
H. scabra	4,30	52%(18)	10–12	32%(24)	—	—	—	—	12–18	87%(54)

Interest had been specially concentrated seeking to know whether the burrowing holothurians would take sand or not. Fortunately by careful observation of the sandy flat of reef, it was found that the surface of the sandy flat was covered with sand of nearly whitish coloration, whereas a few cms. beneath the surface the sand was colored dark or nearly blackish as the result of bacterial fermentations. Therefore by dissecting the animal body the gut contents could be estimated from their colors, in what place they would have been taken, on the surface of sandy flat or in the interior of it. In Table 3, the color of ingested sand in *Holothuria bivittata* is tabulated. Materials dissected were brought from natural habitat at different times.

A. at 1,30 o'clock, when they were just burrowing into the sand,
B. at 11 o'clock, when they were burrowed in the sand,
C. at 18–19 o'clock, within one hour after they had began to feed actively on the sandy flat.

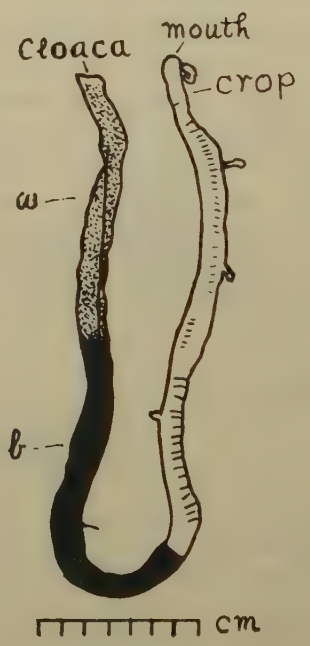


Fig. 2. The alimentary canal of *Holothuria bivittata* collected at 11 o'clock at which it was burrowed in the sand. The anterior half of canal was vacant. The posterior intestinal part was filled with two sorts (*b*, *w*) of sand. *b*: blackish or dark colored gut content taken by animal from the interior of bottom. *w*: the sand derived from the sandy surface. Copied from photograph.

Table 3. The color of ingested sand in the alimentary canal of *Holothuria bivittata*. Stomach and intestine are divided respectively into four parts from anterior to posterior. B, W or W–B denotes a blackish, whitish or intermediately colored gut content respectively, and — means vacant. Observation was carried out on 7/VIII in 1940.

A. Observed at 1,30 o'clock, when animals were just burrowing into the sand.

No.	Total gut content %	Blackish content %	Oesophagus and crop	Stomach				Intestine				Region of cloaca
1	0	0	—	—	—	—	—	—	—	—	—	—
2	100	30	B	B	B	W	W	W	W	W	W	W
3	100	20	B	B	W	W	W	W	W	W	W	W
4	50	10	B	—	W	W	W	—	—	—	W	—
5	80	10	B	W	W	W	W	W	W	W	—	—
6	100	10	B	W	W	W	W	W	W	W	W	W
7	100	10	B	W	W	W	W	W	W	W	W	W
8	100	30	B	B	B	W	W	W	W	W	W	W
9	100	20	B	B	W	W	W	W	W	W	W	W
10	100	20	B	B	W	W	W	W	W	W	W	W
Mean	83%	16%										

B. At 11 o'clock, when animals were found in the sand.

No.	Total %	Blackish %	Oes., crop	Stomach				Intestine				Cloaca
1	10	10	—	—	—	B	—	—	—	—	—	—
2	50	30	—	—	—	—	—	B	B	B	W	W
3	0	0	—	—	—	—	—	—	—	—	—	—
4	40	40	—	—	—	—	—	—	B	B	B	B
5	50	50	—	—	—	—	—	B	B	B	B	B
6	50	50	—	—	—	—	—	B	B	B	B	B
7	50	50	—	—	—	—	—	B	B	B	B	B
8	40	20	—	—	—	—	—	—	B	B	W	W
9	50	35	—	—	—	—	—	B	B	B	W	W
10	5	5	—	—	—	—	—	—	—	—	—	B
11	40	40	—	—	—	—	—	—	B	B	B	B
12	10	10	B	—	—	—	—	—	—	—	—	—
13	50	50	—	—	—	—	—	B	B	B	B	B
14	0	0	—	—	—	—	—	—	—	—	—	—
Mean	32%	28%										

C. At 18–19 o'clock, within 1 hour after they had began to feed on the sandy flat.

No.	Total %	Blackish %	Oes., crop	Stomach				Intestine				Cloaca
1	100	10	W	W	W	W	W	W	W	W	W	B
2	10	10	—	—	—	—	—	—	—	B	—	—
3	30	30	—	—	—	—	—	—	—	B	B	B
4	80	40	W	W	W	W–B	—	—	B	—	—	B
5	80	50	W	W–B	W–B	W–B	W–B	B	B	—	—	B
6	10	5	W, B	—	—	—	—	—	—	—	—	B
7	40	40	B	—	—	—	—	—	B	—	B	B
8	10	10	—	—	—	B	—	—	—	—	—	—
9	60	50	W, B	—	—	—	—	B	B	B	B	W
10	30	15	W	W	B	—	—	—	—	—	B	—
11	40	20	W	W	—	—	—	—	—	—	B	B
12	80	50	W	—	W	W	B	—	B	B	B	—
13	10	10	B	—	—	—	—	—	—	—	B	—
Mean	44%	26%										

One example of the alimentary canal of dissected material is shown in Fig. 2.

The blackish ingested sand in the crop and in the anterior part of stomach indicated without doubt that holothurians swallowed sand from the interior part of the sandy flat during burrowing movement, what would have certainly facilitated their burrowing into the sand (Table 3, A). In 9 animals out of 14 specimens examined, the anterior half of the gut became vacant, while the posterior half was filled with dark colored contents and in 5 animals out of 14 almost the entire alimentary canal was vacant (Table 3, B). Judging from the amount and the site of the ingested sand in the gut, holothurians would have ingested sand to some extent not only during burrowing movement but also in the following early stage of resting in the sand. Then the animals would give up feeding totally, falling, so to speaking, into a "deep sleep." From C in Table 3, it is clear that some animals, though not all, would begin feeding hastily before coming out of the sand (No. 1, 4, 5 and 12). In *Holothuria bivittata* the time from ingestion to egestion of sand covers about 3–5 hours (YAMANOUCHI 1939, p. 612). This is what the characteristics of the gut contents exhibited in Table 3 would indicate as to what had actually happened in the feeding activities of holothurians within 3–5 hours before dissecting the animals.

III. Respiratory Rhythms

By observing the cloacal pulsation during respiration in 8 holothurian species reared in the laboratory aquarium, some interesting results were obtained. In most animals, including man, breathing movement is accomplished by alternate inspiration and expiration of air or water. In holothurians the inspiratory pulsations intervening between two expirations or water spoutings number one or many. This number of inspirations was the thing of importance and of required detailed observation. In some species, for instance *Stichopus variegatus*, the number of inspirations numbered from 1 to 23 (Table 6). After repeated large numbered inspirations, a strong spouting of water followed, gushing out a large volume of water from cloaca. Also at the end of a long series of repeated inspirations, the amplitude of cloacal pulsation became much smaller than at the beginning. By counting the number of inspiratory pulsations between two expirations, it was revealed that there exist different types of respiration in connection with the activity rhythms of holothurians.

In Table 4 the frequency of the inspiratory numbers between two expirations, in three holothurian species in the different states of activity is summarized. In *Holothuria bivittata* and *H. vitiensis*, the 3 inspirations occupied about 50% of the total observed cases when the animals were in the active state of wandering on the sand. In the resting state of being burrowed in the sand, the 1 inspiration covered the range of 90% of the total observed cases. In *H. scabra* the 3 inspirations was in majority in four different activity states; however, at the moment of beginning the burrowing movement and throughout the resting state in the sand, this number of inspirations

Table 4. The frequency of the number of inspirations intervening between two expirations or between two spoutings in three holothurian species in different states.

Animal	*Holothuria bivittata*						*Holothuria vitiensis*						*Holothuria scabra*							
Number of inspiration between two spoutings	On the sand		In the sand		Just emerging out of sand		On the sand		In the sand		Just emerging out of the sand		In the sand		Just burrowing into the sand		In the sand		Just emerging out of the sand	
	cases	%	cases	%	cases	%	cases	%	cases	%	cases	%	cases	%	ccses	%	cases	%	cases	%
1	203	27.8	**1383**	**88.4**	13	21.3	44	14.8	**620**	**91.6**	13	25	4	1.4	—	—	1	0.3	—	—
2	24	3.3	10	0.3	2	3.3	1	0.3	—	—	—	—	1	0.3	—	—	—	—	1	1.0
3	**385**	**52.7**	157	10.0	**44**	**72.2**	**161**	**54.1**	59	8.4	**16**	**30.9**	**181**	**59.2**	**40**	**93.0**	**275**	**92.4**	**34**	**35.9**
4	13	1.8	3	0.2	—	—	3	1.0			1	1.9	3	0.1	—	—	—	—	—	—
5	69	9.2	10	0.7	1	1.6	55	18.5			10	19.2	89	29.1	1	2.3	14	4.7	32	33.7
6	10	1.4	1	0.0	—	—	1	0.3			—	—	1	0.3	—	—	—	—	—	
7	18	2.5	1	0.0	1	1.6	17	5.7			10	19.2	23	7.5	2	4.7	6	2.0	22	23.2
8	1	0.15					1	0.3			—	—	—	—	—	—	—	—	1	1.0
9	4	0.7					10	3.3			1	1.9	1	0.3	—	—	1	0.3	3	3.2
10	—	—					—	—			—	—	—	—			1	0.3	—	—
11	2	0.3					2	0.7			—	—	1	0.3					1	1.0
13	1	0.15					1	0.3			1	1.9	1	0.3					1	1.0
15	—	—					2	0.7			—	—	—	—					—	—
16	—	—					—	—			—	—	1	0.3					—	—
Sum	730	100	1565	100	61	100	298	100	679	100	52	100	306	100	43	100	298	100	95	100
No. of animals	20		19		5		15		16		5		17		3		14		9	

covered over 90% of all observed cases. In three species the number of inspirations was more markedly distributed in a wider range when they were on the sand and wandering actively than when in the sand.

In another word, when being in the active cycle, the animals respirated seemingly on their own accord, and when they were in the resting state being burrowed in the sand, they respirated regularly or uniformly with as few inspiratory pulsations as possible. The regular and stereotyped respiration type in the resting state may be surely related with the necessity of holding their bodies firmly in the sand. This point will be discussed again in connection with the cycle of muscle tonus in the next chapter.

The uniform and stationary type of respiratory movement seems to come from nervous control. In *Holothuria scabra*, just burrowing animals respirated in the same manner as in the sand (Table 4). This holothurian was able to exhibit a daily behavior rhythm following the environmental one even when the animal was entirely deprived of the visceral organs and body fluid (YAMANOUCHI 1939, p. 625).

In holothurian respiration, the intake and expulsation of water are accomplished by the simultaneous cooperative movements of the respiratory trees and the bodily muscular system (CROZIER 1916). In swallowing water, the body wall was broadened and in expelling water out of the body through the cloaca, the circular muscles were in contraction to the effect that the body diminished in size. By the alternate broadening and contracting movements of the whole body in breathing movement, there occur random shaking movements of the medium surrounding the buried holothurian body. To maintain the burrowed state of the holothurian body for hours in the sand, a regular movement of the whole body, in another word, a regular breathing movement is required. In such a way the respiratory type of the 3 sand burrowing species of holothurians is specialized.

The range of distribution of inspiratory number, when the animals were on the sand, covered from 1 to 13 in *Holothuria bivittata*, 1 to 15 in *H. vitiensis* and 1 to 16 in *H. scabra* (Table 4). Whereas these numbers in the resting state in the sand numbered in majority 1 (88.4%) in *H. bivittata*, 1 (91.6%) in *H. vitiensis* and 3 (92.4%) in *H. scabra*. In addition to the interpretation made in the preceding sentence, the following explanation may be stated concerning the respiratory type. In holothurians the rôle of the epidermis is enormous in respiration as WINTERSTEIN[1] (1908) pointed out that about 50% CO_2 is lost in the respiratory trees. In the sand epidermal respiration may be considerably reduced and hence the efficiency of normal respiration through the water-lung should be raised. A rapid respiration (i. e., small numbered inspirations) may be favorable in making gas exchange promptly than the deep breath (i. e., large numbered repeated inspirations) in the sand. The mean time interval of respiration was measured and listed in Table 5. By increasing the number

Table 5.[2] Mean time interval of respirations of different types. 0 denotes inspiration, and | expiration or spouting. The number in brackets denotes the number of animals observed. Temperature of water 28.6–29.7°C.

Type of respiration	0|		000|		00000|		0000000|	
Animal	Mean in second	Number of resp.	Mean in sec.	No. of resp.	Mean in sec.	No. of resp.	Mean in sec.	No. of resp.
Holothuria bivittata	12.1	1369(17)	25.0	334(13)	38.7	24 (4)	46.1	4 (1)
H. vitiensis	11.3	663(14)	22.3	129 (9)	34.9	31 (4)	48.4	30 (4)
Mean	11.7		23.7		36.8		47.8	

of inspirations between two expirations, the respiration time interval became proportionately longer. The respiration accomplished by a large number of repeated inspirations would correspond to a "deep breath" in man. Such "deep breath" could not be observed when holothurians were buried in the sand in their resting state.

The holothurians are able to maintain the burrowing state by regulating the respiratory movement by (1) uniform and short respirations reducing the disturbance

1) Cited from CROZIER 1920.
2) Cited from YAMANOUCHI 1941, p. 141.

of the medium surrounding the buried body to the lowest possible degree and by (2) relatively short respirations making the gas exchange as rapid as possible.

The frequency of the number of inspirations in 8 species of holothurians are summarized in Table 6. It is curious enough that the cases of odd number inspirations was extremely predominant over the even cases in all 8 species observed. Among 5403 (100%) cases, odd case counts 5259 (97%) and even case 144 (3%), and Odd/Even=5259/144=43.5. Omitting the sum of inspiratory number 1 (2625) from the sum of odd cases (5259), then Odd/Even=2634/144=19.2. And also omitting the sum of inspiratory numbers 1 and 3 (4217) from the sum of odd cases (5259), then Odd/Even=1042/100=10.4. The reason for the predominancy of the odd cases over even ones is utterly inaccessible to the present author.

Table 6. Frequency of the number of inspirations intervening between two expirations in 8 species of holothurians.

Animal	No. of animals observ.	Number of inspiration between two spoutings																			Sum			Odd/Even
		1	2	3	4	5	6	7	8	9	10	11	12	13	15	16	17	18	19	20	23	Total case	Odd case	Even case	
Holothuria bivittata	20	1883	38	649	20	75	6	18	1	4	—	2	—	1	—	—	—	—	—	—	—	2694	2632	65	40.5
H. vitiensis	16	733	2	247	3	65	1	24	1	11	—	2	—	2	1	1	—	—	—	—	—	1093	1085	8	135.6
H. scabra	17	5	2	515	3	140	1	43	1	5	2	1	—	2	—	1	—	—	—	—	—	721	711	10	71.1
H. atra	18	—	1	70	1	134	—	29	—	10	—	7	1	1	—	—	—	—	—	—	—	254	251	3	83.7
H. edulis	14	—	—	13	—	47	3	39	1	14	1	7	—	5	2	—	1	—	—	—	—	133	128	5	25.6
H. lecanora var.	5	—	1	8	—	13	—	7	—	3	—	—	—	—	—	—	—	—	—	—	—	80	79	1	79.0
H. sp.[1] (ngallau)	4	3	—	41	1	8	—	4	—	2	—	2	—	—	—	—	—	—	—	—	—	61	60	1	60.0
Stichopus variegatus	15	1	—	1	11	164	30	107	5	20	2	6	1	4	4	—	3	1	2	1	1	364	313	51	6.1
Sum	109	2625	44	1592	39	646	41	271	9	69	5	27	2	15	7	2	4	1	2	1	1	5403	5259	144	62.7

In other 3 species (*Holothuria lecanora* var., *Stichopus variegatus* and *St. chloronotus*) which exhibited typical daily feeding rhythms (Fig. 1, *4-6*) in the natural environment, it was extremely difficult in the laboratory to distinguish whether the animals were at rest or in the active state, as they were unable to burrow into the sand in the resting state, though in the natural environment the distinction of activity state was not difficult to make by observing a large number of animals on the sandy flat.

IV. Change of Muscle Tonus According to the State of Activity

The bodily shape and the mode of movement in holothurians are related with

1) Called by the Natives as "ngallau" or "ganraô" (YAMANOUCHI 1939, p. 628).

and adapted to their life in nature. In *Caudina chilensis* which except for the cloacal region is buried in the sand throughout life, the bodily shape is nearly circular in cross section (YAMANOUCHI 1926, Fig. 1). Holothurians lying on the sea bottom generally have ventrally flattened and dorsally convexed bodily shape in cross section. In this state circular muscles and "muscle-like subepidermal elastic fibers (JORDAN 1914)" on the ventral side are in higher grade of tonus than those of the dorsal side (Fig. 3a). In the sand just the reversed relation is maintained (Fig. 3d).

The cross-sectioned bodily shapes on and in the sand remind us of an isosceles triangle. The base of triangle should be situated on the lower side for stability in the life of holothurians on the sandy flat. The reverse state, that is, the base of

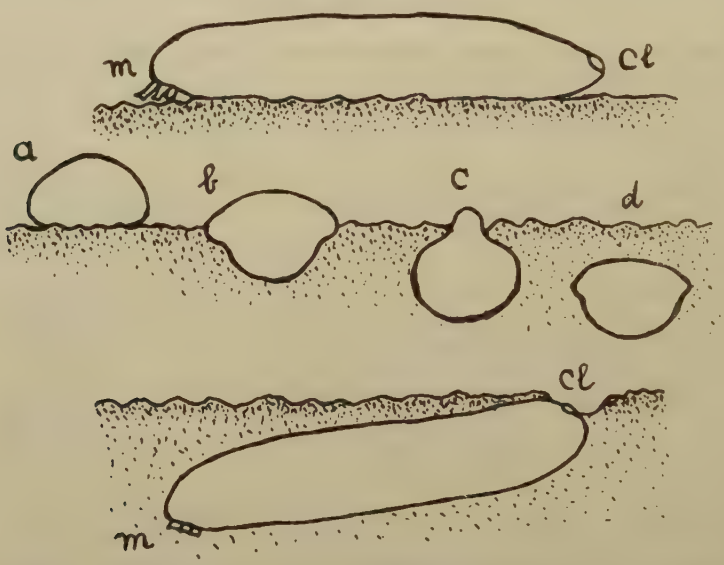


Fig. 3. Schematic drawings of *Holothuria bivittata* on and in the sandy bottom. *M*: mouth; *Cl*: cloaca. a, b, c and d denote the shape of the body in cross section when the animal burrows into the sand. Scale 1/5 natural size.

triangle being on the upper side, seems to be most stable when the animals are burrowed in the sand laying their bodies shallowly close to the bottom surface and holding that state for hours. To conquer the upheaving power coming from the disturbance of the surrounding medium by their breathing movements the only possible and reasonable shape of the body in cross section would the one as drawn in d of Fig. 3.

The holothurians went into the sand "head" first aided by the anteriorly propagating peristaltic muscular waves along the body axis and at the same time by such muscular movements directed downward so that the lower side of the bodies wedged down into the sand (b in Fig. 3) and then it expanded to a circular shape in cross section forcing the sand aside (c in Fig. 3). After burrowing, the ventral side of the animal was stretched out downward continuously along the whole body

axis during the whole times of the "seemingly sleeping" state in the sand (Fig. 3). When the animals came out of the sand after the hours "seeming sleep," the process of movement was rather simple. The holothurians proceeded obliquely in an upward direction until they emerged on to the flat. In this instance the tonic relation of the dorsal and ventral circular muscles and muscle-like elastic fibers were reversed.

PEARSE (1908) reported the process of burrowing in *Thyone briareus* (LESSUEUR) which burrows into the sand, the middle portion of the body first, aided by the action of tube feet, the two ends of the body being turned upward. The process of the downward movement of the body during burrowing in *Thyone* are alike in the main features to those of the holothurians. According to him *Thyone* burrows completely into the sand within 2 to 4 hours. In the holothurians in Palao that time was within half an hour. The difference in the process of the burrowing movement and in its object between the two groups will explain the discrepancy of burrowing times.

V. Reversal of Daily Activity Rhythms under Experimental Conditions

In a previous paper (YAMANOUCHI 1939, p. 624), the behavior of *Holothuria vitiensis* under artificial light in the laboratory has been reported. They had shown the same rhythmic activity of burrowing in and out of the sandy bottom as in the natural habitat, when illuminated from above by 100 watt electric light during the day time. When the aquarium was made totally dark by covers throughout the whole day, their activity rhythm was retained without change for several days, but after one week the daily rhythm became somewhat irregular. Uncovered, they had again exhibited their regular daily rhythm of activity.

In 1940, further experiments had been undertaken concerning the response of holothurians to varied light conditions. 7 specimens of *Holothuria vitiensis* were reared in the laboratory aquarium (80×50 cm, 17 cm sand depth and 50 cm water layer). Illumination of the aquarium was made by 100 watt electric lamp lighted 1 meter above the water level. For several days at the beginning natural light conditions were simulated, and then the light conditions were reversed, that is, during the day time from 6 to 18 o'clock the aquarium was made totally dark by covering it outside with thick black cloth and black paper, and during the night from 18 to 6 o'clock the next morning the aquarium was illuminated by electric light from above. The observation under reversed light conditions was continued for 10 days. The result is shown in Table 7. After three or four days under these unnatural lighting conditions, the activity rhythm of *H. vitiensis* had been completely reversed to accord with the new artificial light conditions. Reversing the light conditions back to the natural cycle, the normal rhythm of activity coming into and out of the bottom sand in accord with the daily cycle of light had been recovered after 2 or 3 days.

Table 7. Behavior of 7 specimens of *Holothuria vitiensis* in the aquarium under dark and light conditions. Number of animals is given, which wandered about on the bottom sand surface of the aquarium. 0 denotes all 7 animals being burrowed in the sand except for the cloacal region, therefore no individium could be found on the sand surface. 3 denotes 3 animals out of 7 being found on the sand sarface and 4 hinding themselves in the bottom sand. Temperature of the sea water varied from 28.6° to 29.7°C. during 17 days (30/VIII–15/IX 1940).

Time / Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
	← dark →						← light →													← dark →						
1	7		7				1			0				0			0		4			7		7	
	← light →						← dark →													← light →						
2			7				0			0			0		0			7	7			3		0	
3							0			0			0		0	1	1	1	7			3		3	
4							0						1			3			2	0	0			0	
5			4				3			5				3		1			0				0		
6							5				7		5			1			0			0			0
7	0							7		5			6			6		0	0	0		0			0
8	0						7			6			5						0			0			0
9	0							7		6			3			0			0				0		
10		0					2			2			3			0			0				0		
11							2			4			2			3			1				0		0
	← dark →						← light →															← dark →			
12	0							3		1			1			0	0		0			0		0	1
13	1						5		0	0			0			0		0	1				5		3
14	3	3				3		1		3			2			0			5			4			
15							1				1			1			2		1			6			5
16	5						0	0		0	1		1			0			5				7		
17								0		0															
Time	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24

From this experiment, it was proved that the daily rhythm of activity in *Holothuria vitiensis* is dependent on the change of external light. The photosensitive area might be the cloacal region, for only this region was exposed to external light when the animals were burrowed in the sand. To prove this, the following procedure had been made: in the laboratory aquarium the cloacal region, continually pulsating for

respiration, had suddenly been illuminated by a strong light flux from a pocket electric lamp. *Holothuria bivittata, H. vitiensis, H. scabra* and *Stichopus variegatus* had reacted to the light beams with a momentary closure of cloaca. Moreover when several individuals of *H. vitiensis* and *H. scabra* were wandering about on the bottom of the darkened aquarium at midnight in the time of their normal active cycle, they were suddenly exposed to the light of a 100 watt electric lamp from above. Most of them had burrowed into the bottom sand after 30 minutes of continuous illumination.

VI. General Considerations

To the group of holothurian feeding uninterruptedly day and night, are added two species inhabiting Japanese waters, *Caudina chilensis* (YAMANOUCHI 1929, p. 75) and *Stichopus japonicus* (YAMANOUCHI 1942, p. 344). Comparing the behaviors of 11 holothurian species observed by the author (3 belonging to A-group, 6 of B-group described in II and 2 of Japanese origin) the type of the daily activity rhythm is regarded to be the character common neither to Genus nor to Sub-genus of holothurians. It is a character specific to each species (YAMANOUCHI 1942). But the species belonging to the same genus bear similar daily activity rhythms as pointed out in Chapter II.

The daily activity rhythms of holothurians were not precisely synchronized with the external light change. The change of sea water temperature was out of question in the tropical sea and the daily behavior rhythm was not correlated with the tidal rhythm (YAMANOUCHI 1939, p. 623). The change of external light was the only external stimulus initiating the peculiar feeding rhythms in the 6 holothurian species previously mentioned. The deviations in behavior rhythms from the natural could be explained by the presence of an endogenous autonomous rhythm specific to each species. MORI (1945) has presented a good example on the relation between the behavior rhythm and the environmental one in the sea pen *Cavernularia obesa*. In this animal the pH change of the body fluid played an important rôle regulating the daily behavior rhythm induced by external light change. In holothurians alike metabolic change should be present, though this has not been investigated. But the case of holothurians was not so simple as that of the sea pen, as 7 specimens of *Holothuria scabra* whose entire visceral organs including body fluid being completely ejected from their cloaca by violent movement, were still able to exhibit normal daily rhythmic activity following the natural cycle of light change. The endogenous metabolic rhythm regulating the behavior should be also sought in such a case in the nervous system itself or in the surrounding medium in the body wall (YAMANOUCHI 1939, p. 625).

Concerning the harmony of the part activity, that is, feeding activity (II), respiratory rhythm (III) and muscle tonus change (IV), in holding the "seeming sleeping" state in the sand, much has been said in the preceding chapters. But a little should

be added as to the origin of the sleeping phenomena of animals. There are some resemblances and differences between the sleep of higher animals and holothurians. The higher animals give up feeding during sleep. This is also true of holothurians, but in them feeding was not yet quite given up at the beginning of the burrowing state and it was began already early before emerging on to the sandy flat. In another word in "shallow" seeming sleep, feeding was not yet given up in holothurians. In the higher animals nearly all muscles of the body, though not all, are relaxed during sleep, whereas in holothurians the dorsal tonic elements were in high tonic condition in contrast to the ventral. The feature of the change of respiratory movement in the awaking and resting states is in good agreement between the two.

The behavior pattern of holothurians in the "seeming sleeping" state in the sand should be ultimately attributed to their adaptation to the fact that holothurians breath with whole body movements in the sand. In the course of evolution, when the animals came to be provided with a central nervous system, especially the brain, sleep, in its true sense, is realized. In the evolutionary stage of possessing a brainless nervous system, the holothurians have exhibited the basic features characterizing sleeping phenomena.

VII. Summary

1. A diagram representing the daily behavior rhythms of 6 holothurian species in the coral reef of Palao Islands was presented. In the species which burrowed in the sand during fast time (*Holothuria bivittata*, *H. vitiensis* and *H. scabra*), feeding was accomplished during the burrowing movement and in the early hour in the sand. It was begun before the time of emerging on to the sandy flat. In the middle period of resting in the sand, feeding was totally given up in these species. A method was found to determine in what place they would have taken sand on the suface or in the interior of the sandy flat.

2. In the sand the number of inspirations intervening between two expirations was maintained constant 1 or 3. In the active state feeding on the bottom sand, this number was variable, fluctuating from 1 to 16. Therefore the type of respiration in the sand should be regarded as stationary and stereotyped. By doing so, the holothurians held firmly their posture in the sand against the upheaving action of the surrounding medium and were able to make gas exchange as rapid as possible. The respiratory rhythm above stated seems to be under nervous control. The odd number of inspirations between two expirations was extremely predominant over the even one (Odd/Even=43,5).

3. The holothurians burrowed into the sand by anteriorly progressive peristaltic muscle waves and by the simultaneous downward directed alternate wedge-shaped stretching out and circularly expanding of the ventral side of the body. The tonus of the circular muscles and muscle-like elastic fibers was reversed alternately on the dorsal and ventral sides according to whether they were on or in the sand. The inverted

triangular bodily shape in cross section in the sand was favorable to maintain the buried state for hours.

4. The interesting facts which characterize the "seeming sleep" of holothurians should be attributed to their adaptation to burial in the sand during a limited time interval (8 to 13 hours) and their breathing with movements of the whole body.

5. Under inverted light conditions, illuminated during the night and made dark during the day, *Holothuria vitiensis* was found to be wandering on the bottom sand in the laboratory aquarium during the day time and buried in the sand during night in accord with the new lighting conditions. Their daily rhythm was thus proved to be dependent on the cycle of external light change.

Acknowledgment

The author wishes to express his sincere gratitude to the Director of the Laboratory, Prof. D. MIYADI and Asst. Prof. H. UTINOMI, Staff Member of the Laboratory, for their kindness giving the author the opportunity of publishing the present article.

Appendix. On the Pearl Fishes in the Palao Island

Among four species of pearl fish known in tropical seas, I have collected three species, that is, *Jordanicus gracilis* (BLEEKER), *Carapus parvipinnus* (KAUP) and *Carapus homei* (RICHARDSON) from several holothurians in the coral reef of the Palao Islands. On this I have already reported in 1938. In 1956 I was asked about pearl fish by Dr. LESTER R. ARONSON at the American Museum of Natural History. It would be by no means useless to describe the relation of the pearl fish to its symbiotic host holothurian. Moreover I have reported on holothurians containing poison in 1955 (YAMANOUCHI 1955). The venom of holothurian poison in concern is given in the last column of the next table.

Holothurian	Pearl fish found	Frequency of pearl fish found	Grade of the venom of holothurian poison
Holothuria argus	*Jordanicus gracilis* *Carapus parvipinnus*	ordinary	++
H. bivittata	sp. not recorded	ordinary	++
H. flavo-maculata	*Carapus homei*	rare	not tested
H. lecanora var.	not found	none	+++
Stichopus variegatus	*C. homei*	rare	++
St. chloronotus	*C. homei*	very abundant	++
Thelenota ananas	*C. parvipinnus*	ordinary	+++

The occurrence of pearl fish symbiotic in holothurians seems to be unrelated with the venom of holothurian poison, but related in the first place with the broadness of the holothurian cloaca, through which pearl fish can penetrate into the gut of its host.

For instance, in *Holothuria lecanora* (JAEGER) var. belonging to sub-genus *Actinopyga* which has small cloaca fringed with radially situated five hard horn-like epidermal processes, no single case of pearl fish symbiosis was found in the waters of Palao.

LITERATURE CITED

CROZIER, W. J. 1916. The rhythmic pulsation of cloaca of holothurians. J. Exp. Zool., vol. 20, p. 297.

——————— 1920. Notes on some problems of adaptation, 3. The volume of water involved in the cloacal pumping of holothurian (*Stichopus*). Biol. Bull., vol 39, p. 130.

JORDAN, H. 1914. Ueber reflexarme Tiere. IV. Holothurien. Zool. Jahrb., Abt. Allg. Zool. u. Physiol., Bd. 34, p. 422.

MORI, S. 1945. General considerations on the relation between the behavior rhythm and the environmental rhythm. Contr. to Physiol. a. Ecol., Kyoto Univ., No. 39 (in Japanese).

FEARSE, A. S. 1908. Observations on the behavior of *Thyone briareus* (LESSUEUR). J. Exp. Zool., vol. 15, p. 259.

YAMANOUCHI, T. 1926. Some preliminary notes on the behavior of the holothurian *Caudina chilensis* (J. MÜLLER). Science Reports Tohoku Imp. Univ., IV Series, Biol., vol. 2, no. 1, p. 86.

——————— 1929. Notes on the behavior of holothurian *Caudina chilensis* (J. MÜLLER). *Ibid.*, vol. 6, no. 1, p. 73.

——————— 1938. Observation of animals in South Sea Islands. Shokubutsu oyobi Dobutsu (Bot. and Zool.), vol. 6, no. 11, p. 1922 (in Japanese).

——————— 1939. Ecological and physiological studies on the holothurians in the coral reef of Palao Islands. Palao Trop. Biol. Stat. Studies, vol. 1, no. 4, p. 604.

——————— 1941. Studies on the useful holothurians in Palao Islands. Kagaku-Nanyô (Science of the south sea), vol. 4, no. 2, p. 36 (in Japanese).

——————— 1942. On the feeding habit of *Stichopus japonicus* SELENKA. Zool. Magaz., vol. 54, no. 9, p. 344 (in Japanese).

——————— 1955. On the poisonous substance contained in holothurians. Publ. Seto Mar. Biol. Lab., vol. 4, no. 1, p. 183.

WINTERSTEIN, H. 1909. Ueber die Atmung der Holothurien. Arch. fisiol., vol. 7, p. 33.

A NEW SPECIES OF MARINE SPIDER *DESIS* FROM JAPAN[1)]

Takeo YAGINUMA
Biological Laboratory, Otemon Gakuin, Osaka

With 5 Text-figures

It has been reported in some papers that the marine spider called only as "*Desis* sp." has occasionally been found in Japan. To date, however, as far as the author is aware, neither a specific description nor a correct identification of it, has yet been made.

Recently the author had an opportunity to study Japanese marine spiders *Desis* which were obtained at Shirahama, Prov. Kii, by Dr. H. Utinomi (Seto Marine Biological Laboratory) and at Tokara Islands, south of Kyushu, by Mr. S. Uéno (Kyoto University).

Marine spiders *Desis* spp. have been found in the tropical and temperate zones of Eastern hemisphere, particularly in the southern part. From the point of their distribution, it is very interesting to know that they are found in Japan, which probably forms the northern limit of their habitat.

The author examined three individuals, of which one is an adult male, and the other two subadult females. As the result of careful comparison (of the arrangement of eyes, teeth of fang furrow and the other characteristics of the main parts of the body) they are found to belong to the same species, although they were collected from different parts of Japan.

The genus *Desis* was established by Walckenaer in 1837, and afterwards some related genera, *Dandridgia*, *Robsonia* and *Paradesis* were created by some arachnologists, but further investigations by Simon and Pocock proved these genera to be *Desis*. The result of the author's investigation determined the present specimens as a new species of *Desis*.

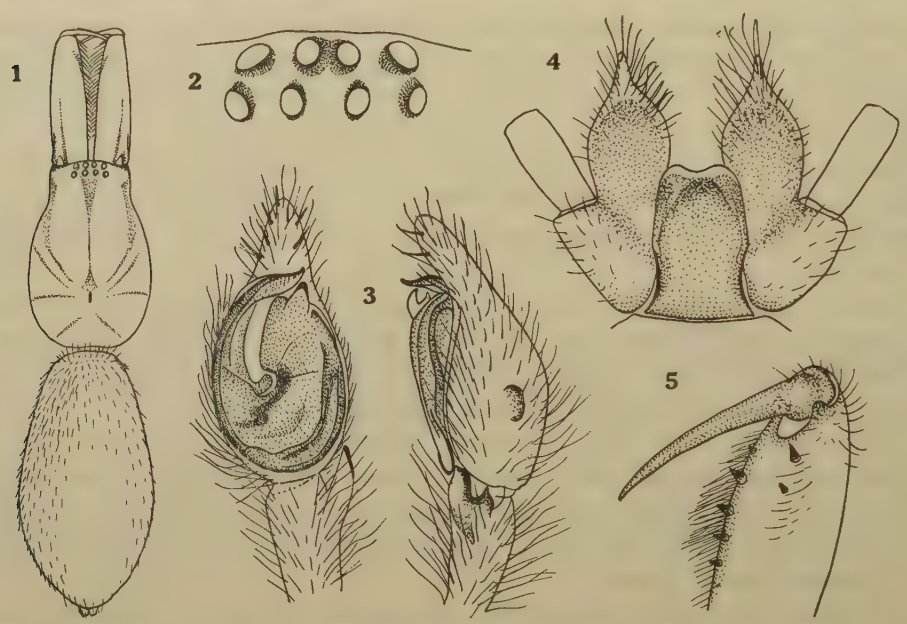
The author wishes to express his hearty thanks to Dr. H. Utinomi, Mr. S. Uéno and Mr. Y. Tsutsui (The leader of the Scientific Survey of the Tokara Islands, and Director of the Osaka Municipal Museum of Natural History) for their kindness in giving him an opportunity to study the materials they collected, and also to Dr. T. Esaki (Kyushu University), Mr. T. Habe (Kyoto University) and Miss C. Okuma (Kyushu University) for presenting the author with references.

1) Contributions from the Seto Marine Biological Laboratory, No. 285.

Desis japonica sp. nov.

Japanese name: Yamato-Ushiogumo

Cephalothorax elongated, longer than first femur, or the combined length of patella and tibia of first leg, square in front, slightly rounded on both sides of thorax. Median furrow short and longitudinal. Cervical groove and radial furrows shallow but distinct. Eyes in two rows. The breadth of eye area one half of that of head. Anterior row of eyes almost straight, posterior row slightly recurved. Posterior row of eyes a little longer than anterior. Anterior median eyes separated from each other



Desis japonica sp. nov.
Fig. 1. Dorsal aspect, legs omitted.
Fig. 2. Eye area.
Eig. 3. Male palp.
Fig. 4. Endites and labium.
Fig. 5. Chelicera.

by less than their own diameter, and from laterals by their own diameter; posterior medians about twice their diameter apart and the distance to laterals 1.5 times their diameter. Median eye area narrower in front than behind. Anterior lateral eyes somewhat larger than posterior laterals. Distance between laterals about one half of the diameter of anterior laterals.

Clypeus very long, projected nearly straight forward, but slightly shorter than the length of carapace, their ratio being about 4 : 5. Chelicera with lateral condyle much hairy at inner side, promargin of fang furrow with seven teeth, their distal small and slightly farther from the base of fang than from the adjacent tooth, the

second, largest of all, and the rest gradually diminishing to the proximal, retromargin with two teeth near the base of fang, of which the distal large, and situated equally from both fang base and the other tooth. Endite long, pointed apically, with long scopulae, inner side parallel. Labium much longer than wide, slightly narrowing anteriorly, extend beyond the middle of endite, slightly depressed at its extremity. Sternum oval and flat with concave emarginations opposite coxae. Legs 1, 4, 2, 3, with scopulas beneath metatarsus of legs 2, 3, 4, each leg with two bristles on femur, the other legs with weak spines as shown in the following table.

Legs		Fem.	Pat.	Tib.	Metatar.	Tar.
I	d	1 1				
	v	(Bristle)				
II	d	1 1				
	v	(„)			2	
III	d	1 1		1	2 2	
	v	(„)		1	2	2 2 2
IV	d	1 1			2 2	
	v	(„)		2	2 2	2 3 2

d···dorsum v···venter

Male palpus long, with bifurcated process on outer side of its tibia. Extremity of palpus with several short stout spines. Embolus running along 3/4 of the circumference of palpus, with its tip bent.

Colour: Carapace reddish brown, deeper anteriorly, especially so at the corners of the head and appear blackish brown. Chelicerae of the same colour as carapace, but fang deep brown. Labium and endites also reddish brown with white tip. Legs yellowish brown but the coxae of 1st legs deep brown. Sternum brown, deeper around the circumference. Abdomen yellow, covered with grey hairs, venter lighter than dorsum.

Measurements: (mm)

Total length (excluding the chelicera) 6.1
Carapace 3.0 Abdomen 4.3
Chelicera 2.3

Legs	Fem.	Pat. & Tib.	Met.	Tar.	Total (excluding Coxa & Troch.)
1	2.4	3.6	2.8	1.6	10.1
2	1.5	2.5	1.2	1.0	6.7
3	1.2	1.8	1.5	0.9	5.2
4	2.1	2.9	2.4	0.9	7.9

Localities and Date:

Shirahama beach (Kii Peninsula) September 1954

♂ adult (collected by Dr. H. UTINOMI)—Holotype—

Takarazima (Tokara Islands) June 1955

2 ♀♀ subadult (collected by Mr. S. UÉNO)

Holotype (S.M.B.L. Type No. 162) is preserved in the collection of the Seto Marine Biological Laboratory.

Remarks: The present species is nearly allied to *Desis marina* (HECTOR), collected in New Zealand, Australia and New Caledonia, in general appearance, but it may be distinguished from the latter in the arrangement of eyes, the relative position of marginal teeth of fang furrow, and the form of embolus which has its extremity bent. Noteworthy characteristics distinguishing this species from other *Desis* are that the posterior median eyes are farther from each other than to the laterals, and that the chelicera is shorter than the cephalothorax.

REFERENCES

BERLAND, L. 1932. Les Arachnides, pp. 132–134.
CAMBRIDGE, O. P. 1879. Proc. Zool. Soc. London, p. 686.
———— 1890. Proc. Zool. Soc. London, p. 625.
CHAMBERLAIN, G. 1947. Rec. Auckland Inst. Mus., vol. 3, p. 158.
ESAKI, T. 1930. Myriapoda and Arachnida (in Japanese), pp. 46–47.
———— 1934. Zoological Dictionary (in Japanese), p. 339.
HECTOR, 1877. Trans. N. Zealand Inst., vol. 10, p. 300.
KISHIDA, K. 1921. Zool. Mag. (in Japanese), vol. 33, no. 390, p. 135.
*KOCH, L. 1872. Die Arach. Austral.
MARPLES, B. J. 1955. Journ. Linn. Soc. Zool., vol. 42, no. 287, p. 502.
MC. KEOWN, K. C. 1952. Australian spiders, p. 169.
OHSHIMA, H. 1930. Zool. Mag. (in Japanese), vol. 42, no. 494, pp. 35–36.
POCOCK, R. I. 1902. Proc. Zool. Soc. London, pp. 98–106.
*———— 1895. Ann. Mag. Nat. Hist., vol. 16.
POWELL, 1879. Trans. N. Zealand Inst., vol. 11, pp. 263–268.
RAINBOW, W. J. 1912. Rec. Aust. Mus., vol. 9, no. 2, p. 258.
SAKAGUCHI, S. 1931. Lansania (in Japanese), vol. 3, no. 23, pp. 33–35.
SAVORY, T. H. 1928. Biology of spiders, pp. 197–198.
SIMON, E. 1898. Hist. Nat. Araig., vol. 2, pp. 225–228.
THORELL, T. 1890–73. Rem. Syn. Europ. Spid., p. 75.
WHITE, A. 1849. Proc. Zool. Soc. London, p. 5.
*WORKMAN, T. G. 1896. Malaysian spiders.

(* not directly referred.)

THE PELAGIC COPEPODS OF THE IZU REGION, MIDDLE JAPAN SYSTEMATIC ACCOUNT II.

FAMILIES PARACALANIDAE AND PSEUDOCALANIDAE

Otohiko TANAKA
Fisheries Department, Faculty of Agriculture, Kyushu University

With 17 Text-figures

Family PARACALANIDAE

Genus *Paracalanus* Boeck, 1884

Three species belonging to this genus have been collected from the Izu region: *Paracalanus aculeatus* Giesbrecht, *P. parvus* (Claus) and *P. denudatus* Sewell. It has been reported by many authors that some of the species have two forms differing from each other mainly in size. The specimens belonging to this genus are, generally, of small size, and structually alike; one cannot get a correct taxomonic determination of the species, unless he observes to every minute point of structure. Moreover, there happens, often, some variations in the armature and structure of the swimming legs, especially, in the 5th legs of the female. From the Japanese waters, Mori recorded the occurrence of *P. aculeatus* and *P. parvus*. Sewell recorded from the Indian seas the occurrence of *P. aculeatus*, *P. serratipes* Sewell, *P. denudatus* Sewell, *P. parvus* (Claus), *P. nannus* Sars, *P. crassirostris* Dahl, *P. dubia* Sewell and *P. nudus* Sewell; he arranged them into two groups, namely, the *aculeatus* and the *parvus* groups; the former three belong to the *aculeatus* and the latter five to the *parvus* group.

Paracalanus aculeatus Giesbrecht

Paracalanus aculeatus Giesbrecht, 1892, p. 146, t. 9; Wolfenden, 1909, p. 998; A. Scott, 1909, p. 26; Sewell, 1914, p. 204; Farran, 1929, p. 222; Sewell, 1929, p. 62; Farran, 1936, p. 79; Mori, 1937, p. 30, pl. 11; Vervoort, 1947, p. 127.

Length. Female; 1.18–1.36 mm. Male; 1.27–1.36 mm.

Remarks. The present female specimen, though much larger in size than those described by Sewell as *P. aculeatus* forma *major* taken from the Indian sea, agrees

fairly well with his description. The lengths of the terminal spine on the 3rd joint of the exopodite of the 2nd and 3rd legs appear somewhat shorter, when compared with SEWELL's figures. A transversal row of the spinules on the distal margin of the 5th legs is much reduced, and only a single spinule was observed near the inner distal margin; in the SEWELL's figure, the spinule on the distal margin is three in number. In the male the proportional lengths of the joint of the left 5th leg differ from those given by SEWELL (1914, p. 208, 15 : 15 : 15 : 12); the 4th joint is the longest in my specimen (20 : 13 : 21 : 25 : 21 = 100).

Occurrence. The species is fairly common, but not abundant.

Distribution. The species appears to be distributed in the tropical and subtropical regions of the oceans. In Japan it has been recorded from the warm regions.

Paracalanus denudatus SEWELL

(Fig. 6, *a–b*)

Paracalanus denudatus SEWELL, 1929, p. 66, fig. 23; FARRAN, 1936, p. 80, fig. 1.

Female. Length, 0.74–0.81 mm. The specimen closely resembles *P. aculeatus* forma *major*. The dorsal profile exhibits a slight hump about the middle of the fused mass of the head and the 1st thoracic segment. The abdomen is contained 3.6-times in the length of the cephalothorax. The abdomen 4-segmented; the segments and furca are in the proportional lengths 35 : 10 : 9 : 24 : 22 = 100; the genital segment wider than long; the genital orifice as that of *P. aculeatus* forma *minor*; the furcal rami about 2-times as long as wide, and set close together.

The 1st antenna exceeds the end of the abdomen by terminal two joints; the distal joint is 1.6-times as long as the penultimate one; the joints 8 and 9 are completely separate; the joints 10 to 22 are furnished with rows of minute spinules on the posterior margin.

In the 1st leg the 1st joint of the exopodite is furnished with a minute outer edge spine. In the 2nd to 4th legs the spinulation on the posterior surface of the 2nd joint of the endopodite, and the outer marginal teeth on the 3rd joint of the exopodite are much reduced; the number of spines on these joints, and the proportional lengths of the 3rd joint of the exopodite to the end spine are as follow:

	Present specimen				SEWELL's specimen				FARRAN's specimen	
	Sp. Ri 2	Sp. Re 3	Re 3	Spt.	Sp. Ri 2	Sp. Re 3	Re 3	Spt.	Re 3	Spt.
2nd	2–3	5–6	100	138	2	5	100	136	100	128
3rd	3–5	8–11	100	118	3	8	100	126	100	104
4th	4–5	7–8	100	109	4	4	100	103	100	85

The 5th pair of legs are small, and resemble those of *P. aculeatus* forma *minor*; the 1st joint about as long as the 2nd; the 2nd joint about 3-times as long as wide, ending in two unequal terminal spines. The other specimen, measuring 0.8 mm, had 3-jointed 5th legs which resemble those of *P. denudatus* figured by SEWELL (fig. 23, *h*); another specimen (0.74 mm) had an abnormal 5th legs as those figured by SEWELL as the 5th legs of *P. aculeatus* forma *minor*.

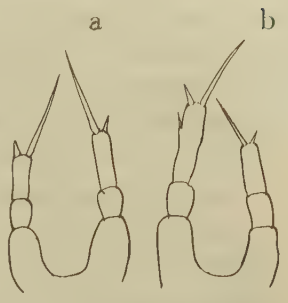


Fig. 6. *Paracalauns denudatus* SEWELL.
a, *b*, Female: abnormal 5th legs.

Remarks. The present specimen, though larger in size than those reported by SEWELL, agrees more closely to *P. denudatus* than to *P. aculeatus* forma *minor* SEWELL in having a long furcal rami, the armature of the 3rd joint of the exopodite, and the proportional lengths of the 3rd joint of the exopodite to the endspine of the 2nd to 4th legs. The 5th pair of legs differ from the type figured by SEWELL, but according to FARRAN, the 5th legs are 3-jointed, and sometimes 2-jointed.

Occurrence. The species has been obtained from the surface; it is not common here.

Distribution. The species has been recorded from the Indian seas and Great Barrier Reef.

Paracalanus parvus (CLAUS)

Paracalanus parvus GIESBRECHT, 1892, p. 164, t. 1, 6, 9; G. O. SARS, 1903, p. 17; ESTERLY, 1905, p. 140; WOLFENDEN, 1906, p. 998; A. SCOTT, 1909, p. 27; SATO, 1903, p. 15; SEWELL, 1914, p. 208; WITH, 1915, p. 54; ESTERLY, 1924, p. 86; G. O. SARS, 1925, p. 24; FARRAN, 1926, p. 233; GURNEY, 1927, p. 143; FARRAN, 1929, p. 221; SEWELL, 1929, p. 68; WILSON, 1932, p. 38; FARRAN, 1936. p. 80; MORI, 1937, p. 29, pl. 11; VERVOORT, 1947, p. 130.

Female. Forma *minor*: length, 0.74–0.82 mm. The head evenly rounded in lateral view; the line of demarcation between the head and the 1st thoracic segment is entirely undetectable. The abdomen is contained 3.7-times in the length of the caphalothorax; the proportional lengths of the abdominal segments and furca 26 : 16 : 13 : 26 : 19 = 100.

The 1st antenna exceeds the end of the abdomen by terminal one joint.

In the swimming legs the number of the outer marginal teeth on the 3rd joint of the exopodite of the 2nd to 4th legs are 8–9, 14 and 17 respectively; in the 2nd and 3rd legs the outer margin between the proximal and the distal spine of the 3rd joint of the exopodite bears two or three spine; these spines are entirely absent in the 4th leg.

The 5th leg 2-jointed; the 1st joint swollen; the 2nd joint 3.7-times as long as wide, and has the inner marginal seta which is little longer than the 2nd joint.

Remarks. The present specimen agrees well with the description and the figures of *P. parvus* given by SEWELL in the following: small in size; the proportional lengths of the abdomen to the cephalothorax; the armature of the exopodite of the 2nd to 4th legs. But the 1st antenna and the endspine on the 3rd joint of the exopodite of the 2nd–4th legs are longer in proportion than those given by SEWELL.

Female. Forma *major*: length, 0.92–0.98 mm. The head separates incompletely from the 1st thoracic segment, and is humped along the dorsal line about the middle. The abdomen is contained about 3.4–times in the length of the cephalothorax; the proportional lengths of the abdominal segments and furca are 27 : 16 : 14 : 25 : 18 = 100; the furcal rami about 2–times as long as wide.

The 1st antenna extends to the end of the abdomen; the terminal joint 1.3–times as long as the penultimate one.

In the swimming legs the proximal outer margin of the 3rd joint of the exopodite of 2nd to 4th legs have 13, 15 and 27 teeth respectively; the proportional lengths of the 3rd joint of the exopodite to the endspine are as follows:

	Re 3	forma *major* Spt.	teeth	Re 3	forma *minor* Spt.	teeth
2nd	100	114	13	100	130	8–9
3rd	100	95	15	100	106	14
4th	100	75	27	100	83	17

The 5th leg 2–jointed; the proximal joint much swollen; the 2nd joint 3.4–times as long as wide, ends in two unequal spines; the spine on the inner distal margin 1.4–times as long as the joint itself.

Remarks. The specimen differs from the foregoing in the following: larger in size; the dorsal line of the head humped; the armature of the exopodite of the 2nd to 4th legs; the proportional lengths of the endspine to the 3rd joint of the exopodite of the 2nd to 4th legs.

Male. Length, 0.84–0.96 mm. The head has a small transparent swelling on the mid-dorsal line about the opposite position to the base of the 1st antenna. The abdomen is contained about 2.0–2.7–times in the length of the cephalothorax; the proportional lengths of the abdominal segments and furca are 10 : 23 : 17 : 18 : 16 : 16 = 100, measured laterally along the dorsal line.

The 2nd joint of the exopodite of the 2nd to 4th legs is dentate on the outer margin; the teeth on the 3rd joint of the exopodite of the 4th leg are finer than those of the female.

The right 5th leg 2–jointed; the left leg 5–jointed; the terminal joint is furnished with two short spines.

Remarks. Two size groups are also detectable in the male of *P. parvus*; the small-sized measured from 0.84–0.88 mm; the large-sized measured from 0.88–0.96 mm;

they differ only in size; the former has somewhat longer abdomen than that of the latter.

Occurrence. The common species in the surface layer in the Izu rigion.

Distribution. The species is widely distributed in the warm regions of the oceans.

Genus *Acrocalanus* Giesbrecht, 1888

Four species belonging to this genus have been recorded from the Japanese waters, of which three species occured in the present collection: *A. gracilis* Giesbrecht, *A. longicornis* Giesbrecht and *A. gibber* Giesbrecht. The genus *Acrocalanus* differs from *Paracalanus* in the following: short abdomen; long 1st antenna; the 4th thoracic segment separates incompletely from the 5th; the armature on the joints of the exopodite of the 2nd to 4th legs; the distal outer margin of the endopodites end in a small spine; the female 5th leg absent or rudimentary; the male 5th legs present only on the left side. The male specimens of *Acrocalanus* resemble so closely each other that it is troublesome to connect the males with the corresponding females. In the present collection, the male specimens are represented by three species *A. gracilis*, *A. longicornis* and *A. gibber*.

Acrocalanus gracilis Giesbrecht

Acrocalanus gracilis Giesbrecht, 1892, p. 171, t. 6, 10; Wolfenden, 1906, p. 1000; A. Scott, 1909, p. 29; Sewell, 1912, p. 395, 359; Sewell, 1929, p. 79; Farran, 1936, p. 81; Mori, 1937, p. 31, pl. 12; Vervoort, 1947, p. 134.

Female. Length, 1.25–1.32 mm. The head is evenly rounded; the line of demarcation between the head and the 1st thoracic segment very slight. The abdomen is contained 3.8-times in the length of the cephalothorax; the abdominal segments and furca in the proportional lengths 31 : 10 : 10 : 24 : 24=100; the furcal rami about 1.7-times as long as wide.

The 1st antenna extends beyond the end of the abdomen by distal three or four joints.

In the swimming legs the basal joints, the exopodite and endopodite are furnished with spinule, but the distal joint of the exopodite of the the 3rd leg has spinules only on the proximal half of the outer margin. The proportional lengths of the 3rd joint of the exopodite to the endspine in the 2nd to 4th legs are 94 : 100, 69 : 100 and 62 : 100 (length of the 3rd point taken as 100). The armature of the outer margin of the 2nd and 3rd joint of the 2nd to 4th legs as follows:

		2nd leg	3rd leg	4th leg
2nd joint		9	9	15
3rd joint	proximal part	8	10	16
	distal part	6	0	14

The 5th pair of legs are, in most cases, absent; some of the specimen had a rudimentary 3-jointed 5th leg on the left side.

Occurrence. A vertical haul from the depth 300 m to the surface contained 19 females.

Distribution. The species appears to be distributed in the tropical and subtropical regions of the oceans.

Acrocalanus longicornis GIESBRECHT

Acrocalanus longicornis GIESBRECHT, 1892, p. 171, t. 6, 10; WOLFENDEN, 1906, p. 1000; A. SCOTT, 1909, p. 28; SEWELL, 1912, p. 358; FARRAN, 1929, p. 222; SEWELL, 1929, p. 82; FARRAN, 1936, p. 80; MORI, 1937, p. 31, pl. 12; VERVOORT, 1947, p. 33.

Female. Length, 1.14–1.28 mm. The head incompletely separates from the 1st thoracic segment; the dorsal profile of the head slightly humped. The abdomen is contained 3.8-times in the length of the cephalothorax; the proportional lengths of the abdominal segments and furca are 33 : 13 : 10 : 20 : 23 = 100; the furcal rami about 2-times as long as wide; the genital segment swollen below.

The 1st antenna extends beyond the end of the abdomen by distal five joints.

In the swimming legs the armature on the outer margin of the 2nd and 3rd joints of the exopodite, and the proportional lengths of the 3rd joint to the endspine of the 2nd to 4th legs are as follows:

		2nd leg	3rd leg	4th leg
Exopod 2		2	7–8	13
Exopod 3	proximal part	5	8–9	14–15
	distal part	5	0	43
Endspine		100	100	100
Exopod 3		86	61	56

The 5th leg absent; but some of the specimen has a rudimentary 3-jointed leg on the left side.

Occurrence. A vertical haul from the depth 300 m to the surface contained 10 female mixed with the foregoing.

Distribution. The species appears to have the similar distribution as that of *A. gracilis*, and has been recorded from the tropical and sub-tropical regions of the oceans.

Acrocalanus gibber GIESBRECHT

Acrocalanus gibber GIESBRECHT, 1892, p. 171, t. 6, 10; WOLFENDEN, 1906, p. 1003; A. SCOTT, 1909, p. 29; SEWELL, 1912, p. 315; SEWELL, 1914, p. 210; GURNEY, 1927, p. 147, fig. 18; SEWELL, 1929, p. 80; FARRAN, 1936, p. 81; MORI, 1937, p. 32, pl. 12; VERVOORT, 1947, p. 136.

Female. Length, 1.13 mm. The dorsal outline of the head is much humped; the separation of the head from the 1st thoracic segment is clearly made out. The abdomen is contained 3.85-times in the length of the cephalothorax; the abdomen 4-segmented, the segments and furca in the proportional lengths 31 : 11 : 10 : 25 : 23=100; the furcal rami about 2.3-times as long as wide.

The 1st antenna exceeds the end of the abdomen by terminal two joints.

The armature on the 2nd and 3rd joints of the exopodite of the 2nd to 4th legs, and the proportional lengths of the exopod 3 to the endspine are as follows:

	2nd leg	3rd leg	4th leg
Exopod 2	7	9	14
Exopod 3 proximal part	9	10	16
Exopod 3 distal part	4	0	5
Endspine	100	100	100
Exopod 3	78	64	55

In the 4th leg the proximal part of the outer margin of the 3rd joint of the exopodite is much longer than the distal part of the same joint.

Occurrence. The species is rare in the Izu region; only one specimen was collected in winter of 1934.

The male specimens of the genus *Acrocalanus* are closely related each other, and differ only in minute points of structure. In the present collection three representatives of the adult male were obtained. In the following I give a table, showing some structural differences in the males and females described by SEWELL:

Species	*A. gracilis*			*A. longicornis*			*A. gibber*		
Total length (mm) male	0.80–1.0			0.95–1.0			0.943		
Proportional lengths									
Abdominal segm. and furca	13 : 26 : 17 : 15 : 16 : 13			12 : 22 : 15 : 15 : 20 : 16			13 : 25 : 17 : 17 : 16 : 12=100		
Joints of 5th leg	25 : 13 : 24 : 20 : 18			23 : 14 : 25 : 20 : 18			26 : 12 : 25 : 22 : 15=100		
Exopod 2	2nd 22	3rd 25	4th leg 25	2nd 22	3rd 27	4th leg 27	2nd 24	3rd 26	4th leg 27
Exopod 3 dist.	19	20	17	22	21	20	19	20	18
Exopod 3 prox.	20	22	28	20	21	24	20	21	23
Endspine	39	33	30	36	31	29	39	33	32
No. of spine Exopod 2	10–11	11–12	17	8–10	12	16–20	11	13	20–22
Exopod 3 dist.	8	14	17	7–9	15	15–20	7–8	14–15	10–11
Exopod 3 prox.	11	15	22	9–10	13	23–25	10	15	25

Total length (mm) female	1.0			1.0			0.81		
Proportional lengths									
Exopod 2	28	26	26	21	27	27	23	27	28
Exopod 3 dist.	19	20	22	22	24	24	20	22	29
Exopod 3 prox.	20	22	23	20	20	22	20	21	27
Endspine	39	32	29	37	29	27	31	30	26

The male specimens of the present collection have the following figures:

Total length (mm)	1.20–1.24			0.955			1.40		
Proportional lengths									
Abdomen segm. and furca	12 : 25 : 18 : 16 : 18 : 11			11 : 24 : 17 : 15 : 20 : 13			13 : 25 : 17 : 17 : 15 : 13=100		
5th leg	24 : 22 : 21 : 17 : 16			23 : 25 : 20 : 17 : 15			18 : 26 : 22 : 18 : 16=100		
Exopod 2	23	27	27	22	27	27	24	25	27
Exopod 3 dist.	18	18	19	18	20	20	17	19	19
Exopod 3 prox.	21	24	25	23	23	20	22	23	22
Endspine	38	31	29	31	30	26	38	33	32

Comparing these figures each other, I am inclined to regard the large specimen (1.20–1.24 mm) as the male of *A. gracilis*, and the small specimen (0.955 mm) as the male of *A. longicornis*, and the largest specimen (1.40 mm) as the male of *A. gibber*.

Acrocalanus gracilis

Male. Length, 1.20–1.24. The proportional lengths of the cephalothorax to the abdomen are 99 to 36, so the abdomen is contained 2.75-times in the length of the cephalothorax. The abdominal segments and furca, measured in dorsal aspect, have the proportional lengths 12 : 25 : 18 : 16 : 18 : 11 = 100 ; the furcal rami 1.3-times as long as wide.

The 1st antenna exceeds beyond the posterior margin of the last thoracic segment by terminal three joints ; the proportional lengths of the joints measured along the posterior margin are :

Joint	1–6	7–8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	286	58	22	27	31	31	40	40	45	45	45	45	45	45	45	45	45	40	27=1000.

The proportional lengths and the armature of the 2nd to 4th legs are as tabulated above.

The immature specimen in the copepodid stage V were also taken associated with the adult males and females. The total length of the specimen measured 1.07–

1.16 mm. The proportional lengths of the 2nd and 3rd joints of the exopodite to the endspine, and the number of spines on the outer margin of the 2nd and 3rd exopod of the 2nd to 4th legs are as follows:

Proportional lengths of the joints	2nd leg	3rd leg	4th leg
Exopod 2	21	24	24
Exopod 3 prox.	21	24	28
Exopod 3 dist.	18	18	18
Endspine	40	34	30
Number of spines on the outer margin			
Exopod 2	1	5	6
Exopod 3	5	6	9

The left 5th leg 4-jointed.

Acrocalanus longicornis

Male. Length, 0.955 mm. The proportional lengths of the cephalothorax to abdomen are 71 : 26, so the abdomen is contained 2.85-times in the length of the cephalothorax. The forehead narrowly rounded; a small transparent swelling is observed on the mid-dorsal line of the cephalon. The line of demarcation between the 4th and 5th thoracic segment can be clearly made out in lateral aspect. The rostrum is rather stout and short. The proportional lengths of the abdominal segments and furca, measured along the dorsal, are 11 : 24 : 17 : 15 : 20 : 13=100; the furcal rami 1.4-times as long as wide.

The 1st antennae reach back beyond the posterior margin of the last thoracic segment by the extent of the terminal three joints; the proportional lengths of the joints measured along the posterior margin are:

Joint	1-6	7-8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	23	25
	274	63	29	34	35	40	40	46	46	46	47	46	46	46	46	46	46	40	29=1000.

The proportional lengths of the joints of 2nd to 4th legs are as tabulated above. The left 5th leg has the joints in the proportional lengths 23 : 25 : 20 : 17 : 15=100; the endspine of the 5th joint about 2/5 the length of the distal joint.

The immature male specimens in the copepodid stage V, measured 0.96-0.97 mm. The specimen has the swimming legs similar in structure to those of the female; the proportional lengths of the various joints and the number of the outer marginal spine on the 2nd and 3rd joint of the exopodite of the 2nd to 4th legs are as follows:

Proportional lengths of the joints		2nd leg	3rd leg	4th leg
Exopod 2		22	26	27
Exopod 3	prox.	20	22	26
	dist.	19	20	20
Endspine		37	32	27
Number of outer marginal spines				
Exopod 2		1	7	8
Exopod 3	prox.	5	6	10
	dist.	5	0	5

The endspine of the last joint of the left 5th leg is longer than that of the immature male of *A. gracilis*.

Occurrence. The adult males of *A. gracilis* and *A. longicornis* were collected in the vertical hauls in Sept. 1937 associated with the adult females.

Acrocalanus gibber

Male. Length, 1.40 mm. The head is evenly rounded; there is a small transparent swelling on the mid-dorsal line about the anterior one third of the head; the line of fusion between the head and the 1st thoracic segment can be made out in lateral aspect. The abdomen is contained 2.8-time in the length of the cephalothorax. The abdominal segments and furca in the proportional lengths 13 : 25 : 17 : 17 : 15 : 13 = 100.

The 1st antennae reach back beyond the posterior margin of the cephalothorax by the extent of two terminal joints.

The proportional lengths of the various joints, and the armature on the 2nd and 3rd exopod of the 2nd to 4th legs are as follows:

Proportional lengths of the joints		2nd leg	3rd leg	4th leg
Exopod 2		24	25	27
Exopod 3	prox.	22	23	22
	dist.	17	19	19
Endspine		38	33	32
Number of teeth				
Exopod 2		15	17	34
Exopod 3	prox.	13	15	29
	dist.	9	15	25

The 3rd joint of the exopodite of the 1st leg has a longitudinal row of spinules on the proximal part along the outer margin.

The 5th leg has the following proportional lengths, commencing from the base: 18 : 26 : 22 : 18 : 16 = 100.

The present specimen agrees fairly well with SEWELL's description of the male of *A. gibber*, but differs from it in the following: larger in size; the length of the 1st antenna; the proportional lengths of the 5th joints of the left 5th leg.

Occurrence. A single specimen in winter of 1934 from the surface.

Genus *Calocalanus* GIESBRECHT, 1888

From the Japanese waters only one species *Calocalanus pavo* (DANA) has been reported. In the present collection the following five species were detected: *C. pavo* (DANA), *C. plumulosus* (CLAUS), *C. styliremis* GIESBRECHT, *C. pavoninus* FARRAN, *C. gracilis* sp. nov.; the last species appears to be undescribed, and to which I give the name *C. gracilis*.

The general character of the genus resembles that of *Paracalanus*, but it is easily distinguished from the former in the segmentation, and the shape of the abdomen, and the proportional lengths of the joints of the 1st antenna.

Calocalanus pavo (DANA)

Calocalanus pavo GIESBRECHT, 1892, p. 175, t. 1, 4, 9; WOLFENDEN, 1906, p. 999; A. SCOTT, p. 30; SEWELL, 1914, p. 214; FARRAN, 1929, p. 222; SEWELL, 1929, p. 89; WILSON, p. 1932, p. 39; FARRAN, 1936, p. 83; MORI, 1937, p. 33, pl. 13. VERVOORT, 1947, p. 138.

Length. Female, 1.23 mm.

Occurrence. The species is not common here; one adult female was obtained in a vertical haul from 50 m to the surface in August 1937.

Distribution. The species is widely distributed in the tropical and subtropical regions of the Pacific, Atlantic and Indian Ocean.

Calocalanus plumulosus (CLAUS)

(Fig. 7, *d–e*)

Calocalanus pulmulosus GIESBRECHT, 1892, p. 176, t. 3, 9, 36; WOLFENDEN, 1906, p. 999; A. SCOTT, 1909, p. 31; SEWELL, 1914, p. 214; FARRAN, 1929, p. 223; SEWELL, 1929, p. 89; WILSON, 1932, p. 41; FARRAN, 1936, p. 83.

Female. Length, 1.00–1.18 mm. The body slender; the abdomen is contained about 5.2-times in the length of the cephalothorax; the abdomen 3-jointed; the furcal rami symmetrical.

The 1st antenna 24-jointed, exceeds the end of the furca; the terminal joint is 2-times as long as the penultimate one. The 5th leg somewhat differs from that figured by GIESBRECHT: the inner marginal seta on the apex of the 3rd joint is very short; the 3rd joint is about 8-times as long as wide, whereas it is 9-times in the GIESBRECHT's figure. Some specimens had slightly asymmetrical 5th pair of legs.

Male. Length, 0.88–0.90 mm. The head separate from the 1st thoracic segment and so is the 4th from the 5th. The abdomen is contained about 3.4-times in the length of the cephalothorax; the proportional lengths of the abdominal segments and furca are 17 : 21 : 19 : 17 : 15 : 12 = 100; the furcal rami about as long as wide.

The 1st antenna 21-jointed, exceeds the end of the cephalothorax by distal five joints.

The 1st leg with an inner marginal seta on the 1st basal joint. The 3rd leg has three groups of spinules on the posterior surface of the 3rd joint of the endopodite; the 2nd joint of the exopodite has a row of leaf-like spines on the outer margin, and also on the inner margin about proximal one-third of the joint. The 4th leg has a group of spinules on the posterior surface of the 3rd joint of the endopodite.

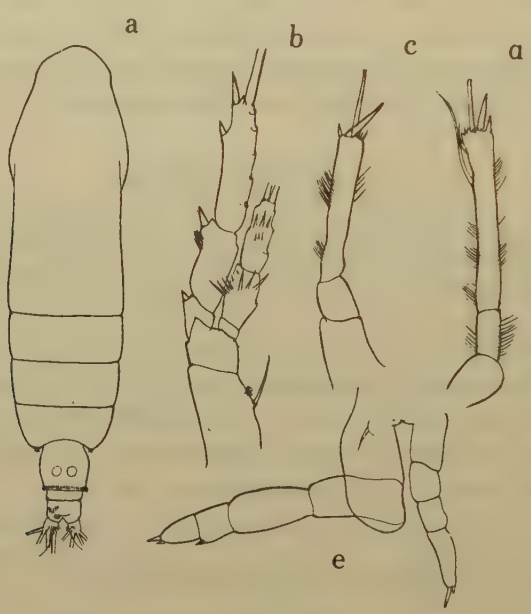


Fig. 7. *Calocalanus plumulosus* (CLAUS).
a, Female: dorsal aspect; *b*, 3rd leg; *c*, 5th leg; *d*, 5th leg, the other specimen; *e*, male: 5th pair of legs.

The 5th legs are similar in structure to those of *Calocalanus pavo*; the left leg 5-jointed; the right leg 4-jointed; the proportional lengths of the joints of the legs as follows:

	1	2	3	4	5
left leg	39	21	23	9	8 = 100
right leg	39	13	17	31	= 100

The proportional lengths of the corresponding joints in C. *pavo*, measured from the GIESBRECHT's figure are:

left leg	30	15	22	22	12 = 100
right leg	36	18	18	28	= 100

Occurrence. Common in the surface layer in summer season.

Distribution. The species is widely distributed in the tropical and sub-tropical regions of the oceans.

Calocalanus styliremis GIESBRECHT

(Fig. 8, *a–b*)

Calocalanus styliremis GIESBRECHT, 1892, p. 176, t. 3, 9, 36; WOLFENDEN, 1906, p. 999; G. O. SARS, 1925, p. 27; FARRAN, 1926, p. 234; FARRAN, 1929, p. 222; SEWELL, 1929, p. 89; FARRAN, 1936, p. 83.

There are two size groups in the female of *Calocalanus styliremis*: the small specimen can easily be referred *C. styliremis* and the large resembles *C. contractus* FARRAN. The small specimen measured 0.60–0.69 mm, and the large 0.75–0.84 mm. The small specimen is robust; the cephalothorax is 2.6–times as long as wide. The large specimen is rather slender and the cephalothorax is about 3–times as long as wide. The abdomen is contained about 5.3–times in the length of the cephalothorax in both specimens. The furca as long as wide. The 1st antenna exceeds the end of the furca by distal five joints; the joints 1 and 2 are separate; the last joint is, in small specimen, less than 2–times the length of the penultimate (21 : 12), whereas it is 2–times in the large specimen (30 : 14–16). The proportional lengths of the outer margin of the 3rd joint of the exopodite and the endspine of the 3rd leg are nearly the same in both specimens:

	proximal	distal	endspine
small-sized specimen	31	11	58
large-sized specimen	31	10	59

The 5th legs of the small specimen resemble those figured by GIESBRECHT; the distal joint is about 4–times as long as wide, and has a slight swelling on the proximal part. In the large specimen the distal joint is about 3–times as long as wide, and carries four spines at the base of the terminal spine.

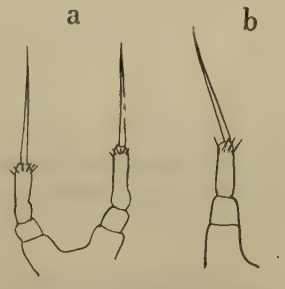


Fig. 8. *Calocalanus styliremis* GIESBRECHT. *a*, Female: 5th pair of legs; *b*, 5th leg of the large specimen.

According to GIESBRECHT the group of the spine on the posterior surface of the endopodite of the 3rd and 4th legs are constant in number, but they are three in the small specimen, and two in the large specimen.

Occurrence. Common, but only the female specimen has been taken in the Izu region.

Distribution. The species has a wide distribution in the tropical and sub-tropical regions of the oceans.

Calocalanus pavoninus FARRAN

(Fig. 9, *a–c*)

Calocalanus pavoninus FARRAN, 1936, p. 83, fig. 3.

Female. Length, 0.72 mm; cephalothorax, 0.62 mm, abdomen, 0.10 mm; so the abdomen is contained 6.2-times in the length of the cephalothorax; the cephalothorax 2.9-times as long as wide. The proportional lengths of the abdominal segments and furca are 43 : 33 : 34 = 100; the genital segment 2-times as wide as long, and has a marked ventral swelling; the anal segment 2-times as wide as long; the furcal rami about as long as wide.

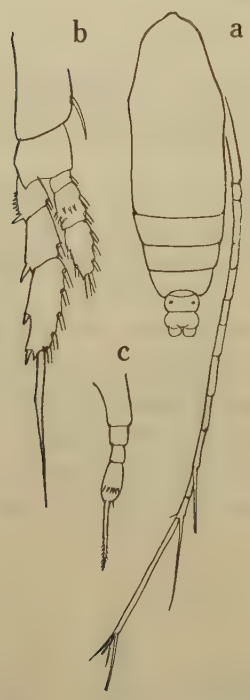


Fig. 9. *Calocalanus pavoninus* FARRAN. *a*, Female: dorsal aspect; *b*, 2nd leg; *c*, 5th leg.

The 1st antennae exceed the end of the abdomen by distal seven joints; the last joint is about 6-times as long as the penultimate one. The 1st leg has 3-jointed exopodite and endopodite. In the 2nd leg the 1st joint of the exopodite has about six teeth-like spines on the outer margin; the 2nd joint of the endopodite has rows of spinules on the posterior surface; the inner marginal seta absent on the 1st basal joint. In the 3rd and 4th legs the 2nd and 3rd joints of the endopodite have each groups of spinules on the posterior surface. The 5th leg 4-jointed; the terminal joint is gradually inflated at the distal end, and about as long as the length of the two basal joints taken together; a line of fusion can be clearly seen at the proximal one-third of the joint; there are a minute spinule at the base of the terminal seta and a transverse row of spinules.

Remarks. The present specimen agrees closely with *C. pavoninus* FARRAN, except minute differences in the structure of the 3rd and 5th legs.

Occurrence. Three adult females in the surface collection in August 1937.

Distribution. The species has been recorded from the Great Barrier Reef region.

Calocalanus gracilis TANAKA

(Fig. 10, *a–e*)

Calocalanus gracilis TANAKA, 1956, p. 7, fig. 3, *a–h*.

Female. Length, 0.62 mm. The body slender; the cephalothorax is 3.5-times as long as wide; the abdomen is contained 4.8-times in the length of the cephalothorax. The abdomen 3-jointed; the proportional lengths of the segments and furca are 40 : 8 : 32 : 20 = 100.

The distal joints of the 1st antenna missing; the proportional lengths of the joints 1–15 in 0.01 mm are as follows:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15
	3.2	4.1	2.3	1.8	2.3	2.3	2.3	3.2	1.8	1.8	2.0	2.3	2.7	2.7

The swimming legs small. The 1st leg has 2-jointed exopodite and 1-jointed endopodite; the 1st basal joint has small spines on the inner distal margin; the proximal joint of the exopodite has a seta on the inner margin about the middle. The 2nd to 4th legs have each 3-jointed exopodite and endopodite; the 1st joint of the exopodite of 2nd leg has four small spines on the outer margin at the base of the outer edge spine; in the 3rd and 4th legs the 2nd and 3rd joints of the endopodite are devoid of groups of spinule on the posterior surface; the leaf-like spines of the 2nd and 3rd joints of the exopodite also absent. The 5th leg 3-jointed; the terminal joint about as long as the 1st, and bears an endspine which is of equal length to the three joints taken together, and have a very minute spine on the outer distal corner of the joint.

Remarks. The specimen resembles *C. tenuis* FARRAN, when viewed from the dorsal, but its small size and the structure of the swimming legs separate the present specimen from the former.

Occurrence. One adult female in the vertical haul from the depth 50 m to the surface in August, 1937. A. FLEMINGER recorded in 1955 the occurrence of the species from the Gulf of Mexico. The description and figures were given in "Breviora," issued from the Museum of Comparative Zoology of Harvard University.

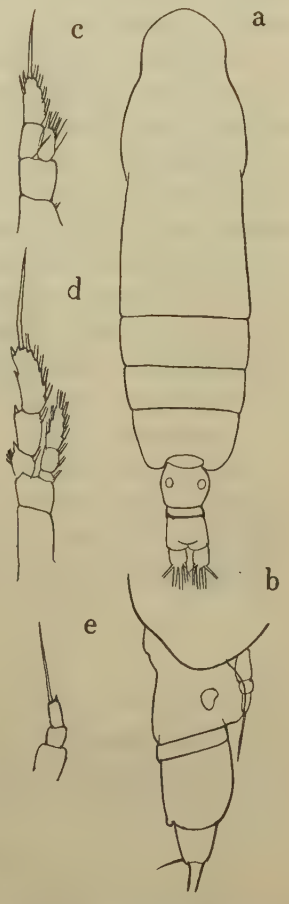


Fig. 10. *Calocalanus gracilis* TANAKA. *a*, Female: dorsal aspect; *b*, 1st thoracic segment and abdomen, lateral aspect; *c*, 1st leg; *d*, 2nd leg; *e*, 5th leg.

Family PSEUDOCALANIDAE

The family, at present, comprises eight genera, namely *Clausocalanus* GIESBRECHT, *Ctenocalanus* GIESBRECHT, *Pseudocalanus* BOECK, *Spinocalanus* GIESBRECHT, *Microcalanus* SARS, *Mimocalanus* FARRAN, *Monacilla* SARS, *Drepanopsis* WOLFENDEN and *Tanyrhinus* FARREN. These genera have the 1st antenna composed of 24 joints; the joints 8 and 9 are completely fused, except those of *Mimocalanus*, *Monacilla* and *Tanyrhinus*. In the swimming legs the exopodite of the 1st to 4th legs are 3-jointed;

the endopodite of the 1st leg 1-jointed, of the 2nd leg 2-jointed, of the 3rd and 4th legs 3-jointed. The number of the outer-edge spine on the terminal joint of the exopodite of the 2nd to 4th legs is three, and the number of the inner marginal setae of the same joints is five. The number of the setae on the distal joint of the endopodite of the 2nd to 4th legs is five, except *Spinocalanus*, *Monacilla* and *Tanyrhinus*; in these three genera the 3rd and 4th legs have four inner marginal setae, whereas in the remaining genera, there are six setae on the terminal joint of the endopodite. In the 1st leg the 1st to 3rd joints of the exopodite have each an outer-edge spine respectively, except *Microcalanus* and *Mimocalanus* which have no seta on the 1st joint of the exopodite, and *Tanyrhinus* which has no outer-edge spine on the 1st and 2nd joints of the exopodite. The armature on the face of the swimming legs are observed in *Spinocalanus*, *Monacilla* and *Drepanopsis*. The female 5th legs are absent or rudimentary, except in *Drepanopsis*. The male 5th legs are, in most cases, uniramose, except in *Spinocalanus* and *Monacilla* which have biramose 5th legs.

Considering the relationship among these genera, it is possible to divide them into the following four groups: (1) *Clausocalanus*, *Ctenocalanus*, *Pseudocalanus* and *Drepanopsis* and *Microcalanus*; (2) *Mimocalanus*; (3) *Spinocalanus* and *Monacilla*; (4) *Tanyrhinus*. FARRAN suggests that *Mimocalanus* is closely allied to *Paracalanus* in the segmentation of the 1st antenna.

Beside these genera, I found from the deep water of Suruga Bay, a specimen which had the swimming legs similar in structure to those of *Spinocalanus*. It differs from the genera given above also in the structure of the male 1st antenna, to which I propose a new generic name *Ryocalanus*.

Genus *Clausocalanus* GIESBRECHT, 1888

At the present time three species have been recorded from the Japanese waters; all of them appeared in the collection, namely; *Clausocalanus arcuicornis* (DANA), *C. furcatus* (BRADY) and *C. pergens* FARRAN.

Clausocalanus arcuicornis (DANA)

(Fig. 11, *a–d*)

Clausocalanus arcuicornis GIESBRECHT, 1892, p. 186, t. 2, 10, 36; ESTERLY, 1905, p. 142; WOLFENDEN, 1906, p. 999; A. SCOTT, 1909, p. 32; SEWELL, 1912, p. 360; G. O. SARS, 1925, p. 27; FARRAN, 1926, p. 237; GURNEY, 1927, p. 150; FARRAN, 1929, p. 223; SEWELL, 1929, p. 90; WILSON, 1932, p. 42; FARRAN, 1936, p. 82; TANAKA, 1937, p. 252; MORI, 1937, p. 34, pl. 13, 14; VERVOORT, 1947, p. 140.

Female. There are two size groups in the female of *C. arcuicornis*. SEWELL described these two forms from the Indian waters. FARRAN reported these two forms in "Copepoda of the Great Barrier Reef Expedition" too. I have detected the two forms from Suruga Bay.

Forma *minor*. Length, 1.18–1.29 mm. The abdomen is contained 3.0–3.4-times in the length of the cephalothorax; the rostrum is slender, and bents slightly backwards. The 5th legs (Fig. 11 *a*) are quite different from those of forma *major* (Fig. 11 *b*).

Forma *major*. Length, 1.41–1.52 mm; the abdomen is contained 2.7–2.8-times in the length of the cephalothorax; the rostrum is stout and rather straight.

Male. Two different types are observed in the male specimen; the difference lies in the structure of the 5th legs; the one, measuring 1.23 mm, has the 5th legs as those hitherto been described (Fig. 11 *b*); the other measuring 1.07–1.29 mm in total length, have a very slender distal joint in the right 5th leg (Fig. 11 *d*). The latter specimens occurred both from the surface and deep waters; the surface specimens are slightly larger (1.23–1.29 mm) than those of the deep waters (1.07 mm).

Occurrence. Very common.

Distribution. The species has a wide distribution in the warm and temperate regions of the oceans.

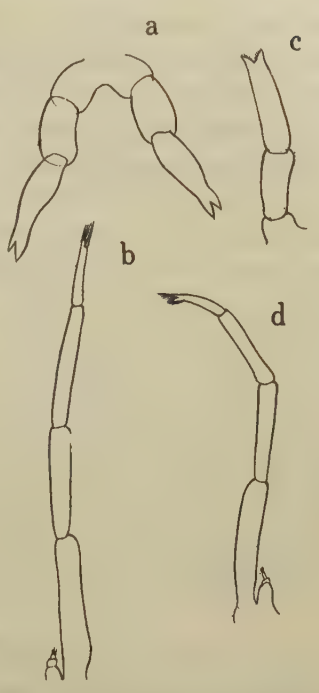


Fig. 11. *Clausocalanus arcuicornis* Dana. *a*, Female, forma *major*: 5th pair of legs; *b*, Male: 5th pair of legs; *c*, Female, forma *minor*: 5th legs; *d*, Male: 5th pair of legs.

Clausocalanus furcatus (Brady)

Clausocalanus furcatus Giesbrecht, 1892, p. 186, t. 36; Wolfenden, 1906, p. 1007; A. Scott, 1909, p. 32; Sewell, 1914, p. 215; Sars, 1925, p. 28; Farran, 1929, p. 225; Sewell, 1929, p. 93; Farran, 1936, p. 81; Mori, 1937, p. 35, pl. 14; Vervoort, 1947, p. 144.

Length. Female, 1.08–1.18 mm. Male, 0.85 mm.

Occurrence. One of the most common species in the Izu region.

Distribution. The species has a wide distribution in the warm region of the oceans.

Clausocalanus pergens Farran

Clausocalanus pergens Farran, 1926, p. 239; Mori, 1937, p. 35, pl. 14.

Female. Length, 0.99 mm. The abdomen is contained 2.8-times in the length of the cephalothorax; the proportional lengths of the abdominal segments and furca are 34 : 21 : 19 : 12 : 14 = 100. The rostrum slender, slightly bent backwards. The 1st

antenna extends to the middle of the genital segment. In the 2nd leg the teeth on the distal margin of the 2nd basal joint are long and slender. The 5th leg ends in two closely-set points.

Occurrence. One adult female from the vertical haul from 1000 m to the surface in Suruga Bay on 25 June, 1937.

Distribution. The species appears to have a wide distribution, and has been recorded from the Bay of Biscay, but not yet from the Indian Seas. In Japan it has been recorded from the warm currents.

Genus *Ctenocalanus* GIESBRECHT, 1888

The genus comprises only one species, *Ctenocalanus vanus* GIESBRECHT. The genus is closely allied to *Clausocalanus*, but is easily distinguished from the former by the ctenate form of the outer edge spine on the 3rd joint of the exopodite of 3rd and 4th leg. In the male the 1st leg has an outer-edge spine only on the terminal joint of the exopodite. *Ctenocalanus longicornis* described by MORI appears to be a synonym of *C. vanus* GIESBRECHT.

Ctenocalanus vanus GIESBRECHT

Ctenocalanus vanus GIESBRECHT, 1892, p. 194, t. 10, 36; ESTERLY, 1924, p. 90; FARRAN, 1929, p. 226; FARRAN, 1936, p. 85; TANAKA, 1937, p. 253; *C. longicornis* MORI, 1937, p. 37, pl. 15.

Length. Female, 1.18–1.27 mm. Male, 1.25–1.40 mm.

Remarks. MORI reported a specimen which has no 5th pair of legs from Japanese waters. The immature male has 4-jointed abdomen; the ctenate outer marginal spines are found in the 3rd and 4th legs; they measured 1.09–1.14 mm.

Occurrence. The species has been collected both from the surface and deep waters, but it is rather abundant in the deep layers.

Distribution. The species is widely distributed in the warm and temperate regions of the Pacific, Atlantic, Red Sea, Mediterranean Sea, San Francisco Bay, La Jolla and also from the Antarctic region, but not from the Indian and Malayan regions.

Genus *Pseudocalanus* BOECK, 1872

Two species have been recorded from the Japanese waters: *Pseudocalanus minutus* (KRÖYER) and *P. gracilis* SARS. One of them appeared in the collection; the species is the inhabitant of northern cold waters.

Pseudocalanus minutus (KRÖYER)

Pseudocalanus elongatus GIESBRECHT, 1892, p. 197, t. 10; SARS, 1908, p 20; SATO, 1913, p. 18; *P. minutus* WITH, 1915, p. 57; WILSON, 1932, p. 43; MORI, 1937, p. 36, pl. 15.

Length. Male, 1.30 mm.

Occurrence. A single male specimen was obtained in a vertical haul from the depth 1000 m to the surface in Sagami Bay, Nov., 1937.

Distribution. The species has a wide distribution in the temperate waters of the North Pacific and Atlantic. It has not been recorded from the Indian Seas.

Genus *Microcalanus* G.O. Sars, 1901

The genus was created by Sars to accomodate a small Calanoid, taken in the Norwegian coast, named *Microcalanus pusillus*; then he added the second species, *M. pygmaeus*, which had been described as *Pseudocalanus pygmaeus*, taken in the Nansen's North Polar Expedition. These two species resemble so closely each other that the distinction between them is very unclear. The generic characters are as follows: the head fused with the 1st thoracic segment, so the 4th with the 5th; the rostrum small; the abdomen 4-jointed; the furca small; the 1st antenna 24-jointed; the oral parts as in *Pseudocalanus* except the slender maxillipede; the swimming legs as in *Pseudocalanus*; the 5th legs absent in the female; the male 5th legs asymmetrical, 6-jointed on the left side.

One species belonging to the genus was found from the intermediate layer of Sagami Bay.

Microcalanus pygmaeus G.O. Sars

(Fig. 12, *a–f*)

Microcalanus pygmaeus Giesbrecht, 1902, p. 000; *M. pusillus* Wolfenden, 1911, p. 000; *M. pygmaeus* With, 1915, p. 66; Farran, 1929, p. 226; Jespersen, 1934, p. 50.

Female. Length, 0.85 mm, cephalothorax 0.64 mm, abdomen 0.21 mm; the abdomen is contained 2.9-times in the length of the cephalothorax. The cephalothorax ovate; the greatest width about half the length of the cephalothorax. The head fused with the 1st thoracic segment; the last two thoracic segments are fused; the lateral corners of the last thoracic segment narrowly rounded at the apex. The rostrum pointed, directs slightly posteriorly. The abdomen 4-jointed; the segments and furca in the proportions 37 : 21 : 17 : 17 : 8=100; the genital segment rounded, about as long as wide, and produced considerably below; the furcal rami slightly longer than wide.

The 1st antenna 24-jointed, extends at least to the distal margin of the 3rd abdominal segment. The 2nd antenna has the exopodite longer than the endopodite (15 : 11); the 2nd joint of the exopodite has three setae; the 3rd has one seta. The mandible has the exopodite slightly shorter than the endopodite (4 : 5). The Maxilla and maxillipede are as those of *M. pusillus* illustrated by G. O. Sars.

In the 1st leg the outer marginal spines on the 2nd and 3rd joints long and curved inwards. In the 2nd leg the terminal spine of the exopodite about as long as

the combined lengths of the three joints of the exopodite taken together, and has 27 serrations; in the GIESBRECHT's specimen the number of the serration is about 40. The terminal spine of the exopodite of the 3rd leg broken off. The 4th leg abnormal: the exopodite 2-jointed, the 2nd basal joint has spinules on the distal inner margin at the base of the endopodite.

Remarks. The specimen, though resembles closely *M. pusillus*, differs from it in the length of the terminal spine, and the number of serration on the exopodite of the 2nd leg. *M. pygmaeus*, taken from the Antarctic, has comparatively long 1st antenna extending to the anterior margin of the anal segment and has the terminal spines of

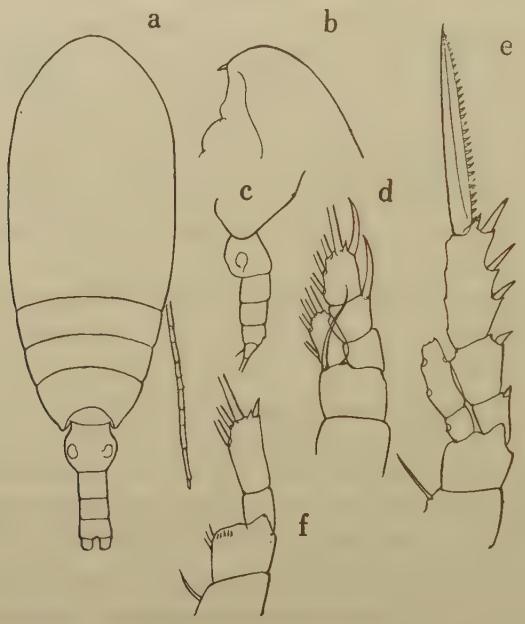


Fig. 12. *Microcalanus pygmaeus* G. O. SARS.
a, Female: dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; *d*, 1st leg; *e*, 2nd leg; *f*, abnormal 4th leg.

the exopodite of the 2nd to 4th legs longer and more finely toothed when compared with those of *M. pusillus* which has only 16 teeth on the terminal spine of the 2nd leg. *M. pygmaeus* was originally described by Sars from the specimen taken in the Arctic region. GIESBRECHT described the same species taken from the Antarctic regions. According to WOLFENDEN *M. pygmaeus* described by GIESBRECHT is not identical with *M. pygmaeus* G. O. SARS, but identical with *M. pusillus* G. O. SARS. SARS stated in his description that in *M. pusillus* the 1st antenna is much shorter than that of *M. pygmaeus*, scarcely extending beyond the end of the genital segment; the swimming legs of *M. pusillus* are less slender than those of *M. pygmaeus*; the terminal

joint of the exopodite of the 2nd to 4th legs comparatively broader, and has the apical spine remarkably dilated, cultrate in shape, and very coarsely serrated. The present specimen agrees more closely with the Antarctic specimen of *M. pygmaeus*, described by GIESBRECHT or FARRAN in the structure of the swimming legs than with *M. pusillus* G. O. SARS.

Occurrence. One female in the vertical haul from the depth 500 m to 300 m, in Sagami Bay.

Distribution. The species has a bipolar-epiplanktonic distribution. It has been recorded from the Arctic regions by G. O. SARS, WITH and JESPERSEN. From the Antarctic it has been reported by GIESBRECHT, WOLFENDEN and FARRAN. The species has not yet been recorded from the Indian and Malayan regions.

Genus *Mimocalanus* FARRAN, 1908

The genus was created by FARRAN to accomodate a number of species closely related to *Spinocalanus*. FARRAN described two species belonging to the genus, namely *Mimocalanus cultrifer* and *M. nudus*, one of which appeared in the collection. The genus is characterised by the followings: absence of rostral filament; the separation of the last two thoracic segments; the equal branches of the 2nd antenna; the large two-branched palp of the mandible, of which the inner being longer than the outer; the maxillae and maxillipede being of *Paracalanus* type; the 1st to 4th legs with jointing and setae as in *Spinocalanus* except that the outer-edge spine on the 1st joint of the exopodite of the 1st leg is absent; the terminal spine of the exopodite of the 2nd to 4th legs are of cultrate form; no spinules on the faces of the legs; the 5th leg absent in the female; the male 5th legs 5-jointed on left side, 4-jointed on the right.

Mimocalanus cultrifer FARRAN

(Fig. 13, *a–i*)

Mimocalanus cultrifer FARRAN, 1908, p. 23, pl. 1; FARRAN, 1926, p. 244; VERVOORT, 1947, p. 156.

Female. Length, 1.50 mm; cephalothorax, 1.11 mm, abdomen, 0.29 mm; the cephalothorax oblong ovate in dorsal view, contracts anteriorly and the frontal margin is vaulted; the head fused with the 1st thoracic segment; the last two thoracic segments separate, but the line of suture very faintly detectable; the lateral corners of the last thoracic segment narrowly rounded at the apex; the rostrum absent. The abdomen 4-jointed, contained 4-times in the length on the cephalothorax; the segments and furca in the proportions 49 : 16 : 13 : 19 : 13 = 100; the genital segment about as long wide and moderately produced ventrally; the furcal rami as long as wide.

The 1st antenna 24-jointed, exceeds the distal margin of the furca by last one or two joints; the proportional lengths of the joints measured along the posterior margin

as follows:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15	16	17
	47	35	18	18	23	23	23	52	35	35	41	47	52	52	52	52
	18	19	20	21	22	23	24	25								
	52	58	52	47	52	52	47	35 = 1000;								

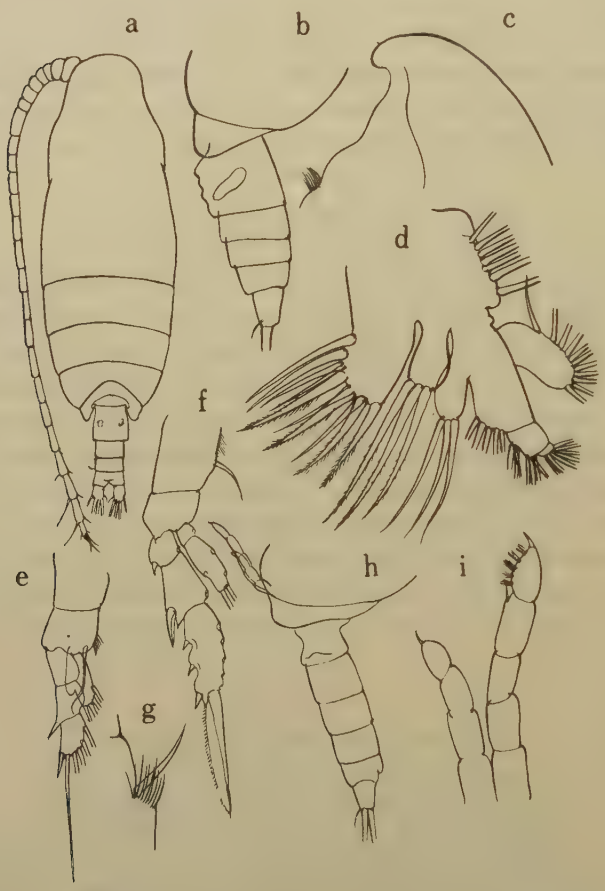


Fig. 13. *Mimocalanus cultrifer* FARRAN.
a, Female: dorsal aspect; *b*, last thoracic segment and abdomen, lateral aspect; *c*, head, lateral aspect; *d*, 1st maxilla; *e*, 1st leg; *f*, 2nd leg; *g*, 1st basal joint of 4th leg; *h*, Male: last thoracic segment and abdomen, lateral aspect; *i*, 5th pair of legs.

the joints 8 and 9 are incompletely fused; the joints 10 and 11 are slightly inflated. The 2nd antenna with the exopodite about as long as the endopodite; the 1st and 2nd joints of the exopodite has 9 marginal setae. The mandible has the exopodite slightly shorter than the endopodite. The 1st maxilla slightly differs from that described by FARRAN; the outer lobe has 7 setae, of which the proximal one is short;

the exopodite has 11 setae; the endopodite has 7+4+3 setae; the 2nd basal joint has 5 setae; the 3rd inner lobe has 3, the 2nd lobe has 4, the 1st lobe has 10 setae; the setae on the inner lobes are strong. The 2nd maxilla has 6 setae in all on the joints of the endopodite, but they are unmodified. In the maxillipede the combined lengths of the joints of the endopodite much longer than the 1st basal joint; the 2nd basal joint short.

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the 1st joint of the exopodite has no outer-edge spine. The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the outer-edge spine on the 2nd joint of the exopodite is the longest; the terminal spine of the exopodite finely serrated; the 3rd joint of the exopodite has 5 inner marginal setae. The 3rd and 4th legs have each 3-jointed exopodite and endopodite. The 4th leg has a row of stiff hairs on the inner margin of the 1st basal joint at the base of the inner marginal seta.

Male. Length, 1.28 mm; cephalothorax 0.98 mm, abdomen 0.3 mm. The general appearance as those of the female. The abdomen 5-jointed, and is contained 3.25-times in the length of the cephalothorax; the segments and furca in the proportions 19 : 18 : 18 : 15 : 18 : 12 = 100.

The 1st antenna exceeds the end of the furca by last two joints. Mouth parts and the swimming legs as those of the female.

The 5th pair of legs asymmetrical: the right side 4-jointed, the left side 5-jointed; the distal joint has hairs on the inner margin.

Remarks. The specimens agree fairly well with *M. cultrifer* which FARRAN collected from the Irish Atlantic Slope.

Occurrence. Two females and a male from Sagami Bay in the vertical haul from the depth 500 to 300 m, Nov., 1937.

Distribution. The species has only been recorded from the deep water of the Irish Atlantic Slope, but its geographical distribution is extended to the Celebes Sea in the Snellius Expedition.

Genus *Spinocalanus* GIESBRECHT, 1888

There has only one species of the genus *Spinocalanus* been known in the Japanese waters, namely *Spinocalanus abyssalis* from the deep water of Suruga Bay. The present collection added four more species: *Spinocalanus spinosus* FARRAN, *S. magnus* WOLFENDEN *S. angusticeps* G. O. SARS and *S. longipes.* The last species has not yet been described, and I propose a new name *longipes.*

Spinocalanus abyssalis GIESBRECHT

Spinocalanus abyssalis GIESBRECHT, 1892, p. 209, t. 13, 36; SARS, 1903, p. 22, 157; WITH, 1915, p. 69; FARRAN, 1926, p. 242; FARRAN, 1929, p. 227; JESPERSEN, 1934, p. 51; TANAKA, 1937, p. 253, fig. 4; VERVOORT, 1947, p. 147.

Remarks. The Atlantic specimen of *S. abyssalis* varies in size from 0.95 to 1.86 mm. FARRAN proposed a new variety name, var. *pygmaeus*, for the small form measuring 0.95–1.1 mm. GIESBRECHT's specimens measured 1.1–1.25 mm; WITH's 1.73–1.86 mm; FARRAN's 0.95–1.86 mm; my specimen 1.01–1.93 mm.

Occurrence. Both size groups occurred commonly in the waters below 200 m.

Distribution. According to FARRAN the small form is less than half as plentiful as the large form above 300 fathoms, but below that depth it becomes much more numerous. *S. abyssalis* has been said to be of Arctic origin, and widely distributed in the deep waters of the oceans but it has not been recorded from the Indian and Malayan regions.

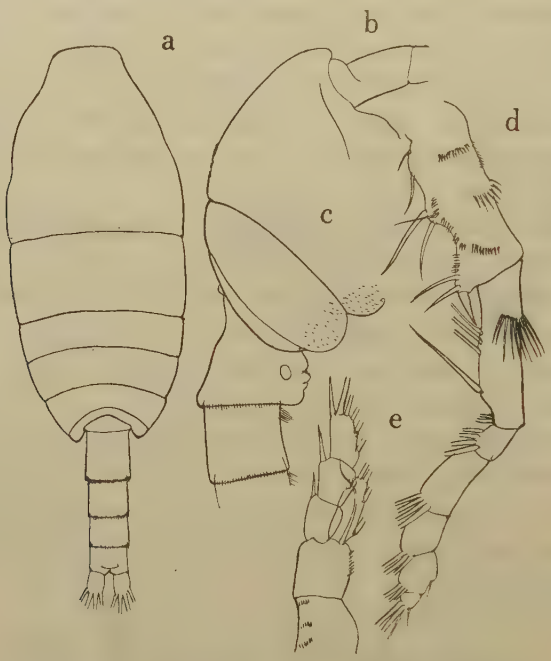


Fig. 14. *Spinocalanus spinosus* FARRAN.
a, Female: dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and genital segment, lateral aspect; *d*, maxillipede; *e*, 1st leg.

Spinocalanus spinosus FARRAN

(Fig. 14, *a–e*)

Spinocalanus spinosus FARRAN, 1908, p. 27; *Spinocalanus horridus* WOLFENDEN, 1911, p. 216; *S. spinosus* FARRAN, 1929, p. 227; VERVOORT, 1947, p. 153.

Female. Length, 2.47 mm; cephalothorax, 1.70 mm, abdomen, 0.77 mm. The head separates from the 1st thoracic segment; the last two thoracic segments are fused;

the lateral corners of the last thoracic segment rounded; the lateral face of the thoracic segments are finely spinulose; the rostrum absent.

The abdominal segments and furca in the proportions 28 : 21 : 21 : 16 : 14 = 100; the genital segment about as long as wide; the ventral surface of the segment has irregular swellings on the genital area; the 2nd and 3rd gegments hirsute on the proximal margin on the ventral surface; the furcal rami about 1.3-times as long as wide.

The 1st antenna exceeds the end of the furca by distal four joints. The 2nd antenna with the exopodite 1.5 times as long as the endopodite. The mandible hirsute on the 2nd basal joint. The maxilla and maxillipede as those of *S. abyssalis*, but the 1st basal joint of the maxillipede has a row of long spines which is entirely absent in *S. abyssalis*, about the middle of the posterior margin.

The swimming legs have general resemblance to those of *S. abyssalis*.

Remarks. According to FARRAN the size of the animal varies from 1.85 to 2.0 mm in the West coast of the Ireland, and 2.13 to 2.45 mm in the Antarctic. WOLENDEN's *S. horridus* is identical with *S. spinosus*, which measured 2.35 mm in total length.

Occurrence. Ten females were taken in Sagami Bay, Nov. 1937, from the depth 1200–0 m.

Distribution. The species has been recorded from the West Coast of Ireland, Bay of Biscay, and Antarctic. The species has a fairly wide distribution in the deep waters of the oceans.

Spinocalanus magnus WOLFENDEN

(Fig. 15, *a–g*)

Spinocalanus magnus FARRAN, 1908, p. 27; WOLFENDEN, 1911, p. 216; G. O. SARS, 1925, p. 33; FARRAN, 1929, p. 227; SEWELL, 1929, p. 95; JESPERSEN, 1934, p. 52; VERVOORT, 1947, p. 150.

Female. Length, 2.50 mm; cephalothorax, 2.00 mm. The cephalothorax elongate ovate; the last thoracic segment not produced as that figured by G. O. SARS. The abdomen 4-segmented, the segments and furca in the proportions 36 : 14 : 11 : 18 : 21 = 100; the genital segment produced below; the genital part has irregular swellings; the furcal rami 1.5-times as long as wide.

The 1st antenna were broken off in all specimens. The 2nd antenna has the exopodite about as long as the endopodite; the other mouth parts as described by WOLFENDEN.

In the 1st leg the 2nd basal joint has several spinules on the inner distal margin. The 2nd leg has 3-jointed exopodite and 2-jointed endopodite, the 2nd and 3rd joints of the exopodite, and the 2nd joint of the endopodite are each furnished with a row of spinules. The 3rd and 4th legs have each 3-jointed exopodite and endopodite. The 5th leg absent.

Male. Length, 2.13 mm. The general appearance as in the female. The abdomen is contained 2.7-times in the length of the cephalothorax; the abdomen 5-segmented, the segments and furca in the proportions 15 : 19 : 14 : 21 : 10 : 21 = 100; the furcal rami 2-times as long as wide. The 1st antenna reaches back to the end of the furca. The 1st to 4th legs as those of the female. The 5th pair of legs have 3-jointed exopodite and 2-jointed endopodite on each side.

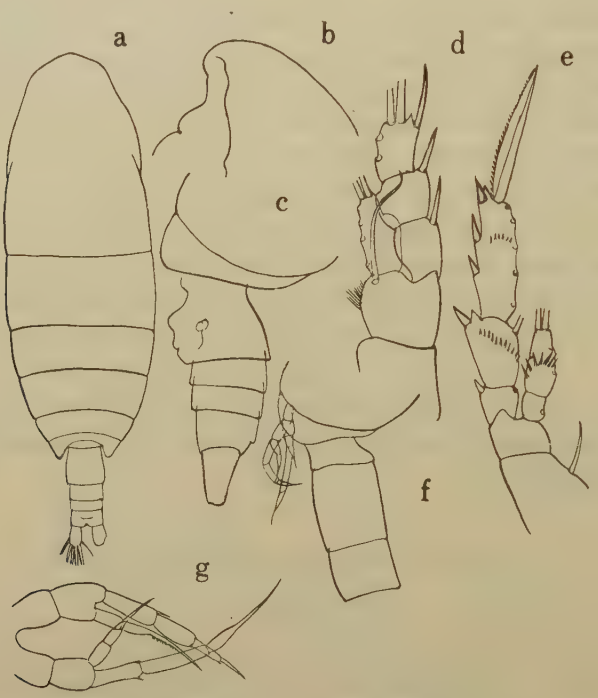


Fig. 15. *Spinocalanus magnus* WOLFENDEN.
a, Female: dorsal aspect; *b*, head. lateral aspet; *c*, last thoracic segment and abdomen, lateral aspect; *d*, 1st leg; *e*, 2nd leg; *f*, Male: last thoracic segment and abdominal segments, lateral aspect; *g*, 5th pair of legs.

Occurrence. Seven females and one male from the depth 1000 m to the surface in both Sagami and Suruga Bay.

Distribution. It has been recorded from the deep waters of the Pacific, Atlantic and Indian Oceans.

Spinocalanus angusticeps G. O. SARS

(Fig. 16, *a–f*)

Spinocalanus angusticeps SARS, 1920, p. 3; G. O. SARS, 1925.

Female. Length, 2.33 mm; cephalothorax, 1.86 mm; abdomen, 0.47 mm. The head separates from the 1st thiracic segment; the last two thoracic segments separate. The head contracts laterally in front when viewed from the dorsal. The lateral corners of the last thoracic segment rounded. The rostrum absent.

The abdomen 4-jointed, contained 4-times in the length of the cephalothorax; the segments and furca in the proportions 37 : 19 : 16 : 14 : 14 = 100; the genital segment produced rectangularly below; the furcal rami slightly wider than long; the 1st to 3rd segments are furnished with fine teeth on the distal margin.

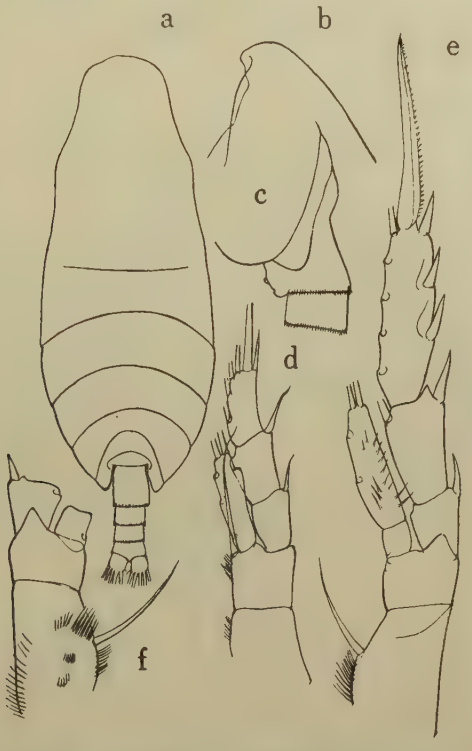


Fig. 16. *Spinocalanus angusticeps* G. O. Sars.
a, Female; dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and gehital segment, lateral aspect; *d*, 1st leg; *e*, 2nd leg; *f*, basal joints of 4th leg.

The 1st antenna broken off in the distal part; the 2nd joint is very long, about 3-times as long as the 3rd. The 2nd antenna has the exopodite shorter than the endopodite (30 : 35). The mandible has the exopodite about as long as the endopodite. The 1st maxilla has a large exopodite, carrying nine setae; the endopodite small; the outer lobe has nine setae. The 2nd maxilla without any noticeable feature. The maxillipede has a long endopodite resembling that of *S. abyssalis*.

The 1st leg has 3-jointed exopodite and 1-jointed endopodite. The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the 2nd joint of the endopodite is furnished with spines on the posterior surface. The 3rd and 4th legs have each 3-jointed endopodite; the 2nd and 3rd joint of the endopodite are furnished with spinules on the posterior surface; the 1st basal joint is furnished with hairs as shown in the figure.

Remarks. The species is easily recognised by the peculiar shape of the head.

Occurrence. Three females in the vertical hauls from the depth 1000 m to the surface in Sagami, Nov., 1937.

Distribution. The species has been recorded from the temperate region of the Atlantic near the Azores Islands.

Spinocalanus longipes sp. nov.

(Fig. 17, *a-f*)

Male. Length, 1.59 mm; cephalothorax, 1.16 mm; abdomen, 0.43 mm; so the abdomen is contained 2.7-times in the length of the cephalothorax. The head separates from the 1st thoracic setment, and the 4th incompletely from the 5th. The last thoracic segment slightly emarginate on the postero-lateral corners. The rostral filament absent. The abdomen 5-segmented; the segments and furca in the proportions 10 : 31 : 22 : 21 : 6 : 10 = 100; the furcal rami slightly longer than wide (5 : 4).

The 1st antennae extend about to the distal margin of the abdominal segment; the right antenna 22-jointed, the joints 8-9-10, 20-21 are fused; the left antenna 23-jointed, the joints 20 and 21 are separate; joints of the antenna measured along the posterior margin are in the fcllowing proportions:

Joint	1	2	3	4	5	6	7	8-9-10	11	12	13	14	15	16	17
	71	54	24	30	30	30	30	95	29	36	35	35	42	48	47

	18	19	20	21	22	23	24	25
	54	54	47	36	48	47	54	24 = 1000

The 2nd antenna has the exopodite 1.25 times as long as the endopodite. The mandible has a robust and round 2nd basal joint; the exopodite about as long as the endopodite. The maxillae reduced. The maxillipede resembles that of *S. abyssalis*; the 2nd joint of the endopodite is long; the 5th joint comparatively large, and carries two long setae and two short ones.

The 1st leg with 3-jointed exopodite and 1-jointed endopodite. The 2nd to 4th legs broken off; the basal joints are furnished with spinules.

The left 5th leg is long and slender, it is much longer than the combined length of the abdominal segments and furca, the 2nd basal joint has a rudimentary endopodite; the right leg short, about as long as the 1st basal joint of the left leg.

Remarks. Although the swimming legs which is the important character of the genus were broken off, the absence of the rostrum, and the features of the joints of the maxilliped, may indicate that the specimen belongs clearly to the genus *Spinocalanus*. The 5th pair of legs are quite different from those hitherto been described and figured.

Occurrence. One male in the vertical haul from the depth 1000 m to the surface in Sagami, Nov., 1937.

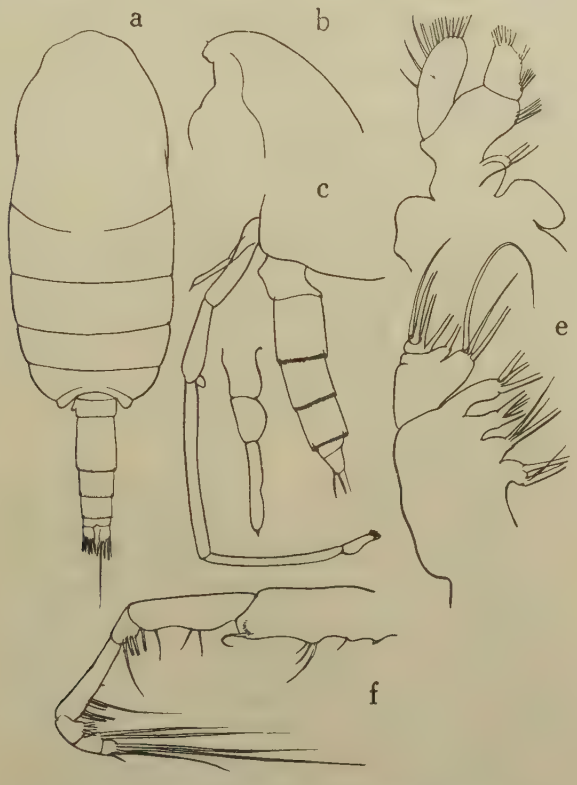


Fig. 17. *Spinocalanus longipes* sp. now.
a, Male: dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and abdomen, lateral aspect; d, 1st maxilla; *e*, 2nd maxilla; *f*, maxillipede.

Genus *Monacilla* G. O. Sars, 1905

G. O. Sars described in 1905 a new species of Calanoida under the name *Monacilla typica*. Farran (1908) described *Oxycalanus spinifer* which is congeneric with the former. In 1909 A. Scott described two species *Oxycalanus semispinus* and *Monacilla dubia*. But according to Sars these two species are two sexes of *Monacilla typica*. In the present collection two species were collected, namely *Monacilla typica* G.O. Sars

and *M. gracilis* WOLFENDEN. The genus has the following characters: the head fused with the 1st thoracic segment, and so are the 4th with the 5th; the rostrum consists of two strong spines, directing ventrally; the abdomen 4-jointed; the 1st antenna 23-jointed, the joints 8 and 9, 24 and 25 are fused; the 2nd antenna, maxilla and maxillipede are of *Pseudocalanus* type; the 1st to 4th legs as in *Spinocalanus*; the distal joint of the endopodite of the 2nd to 4th legs has 5, 6, 6 setae respecitively; in this the genus is closely related to *Spinocalanus* but, the spinulation on the faces of the joints are reduced than in *Spinocalanus*; the 5th leg absent in the female, in the male 5th legs 5-jointed on each side and uniramose.

Monacilla typica G. O. SARS

(Fig. 18, *a–h*)

Monacilla typica SARS, 1905, p. 9; *Oxycalanus spinifer* FARRAN, 1908, p. 35; *O. semispinus* A. SCOTT, 1909, p. 35; *Monacilla typica* G. O. SARS, 1925, p. 38; VERVOORT, 1947, p. 158.

Female. Lengh, 2.25 mm; cephalothorax, 1.77 mm, abdomen, 0.48 mm. The cephalothorax oblong ovate; the head separates from the 1st thoracic segment; the last two thoracic segments fused; last thoracic segment slightly asymmetrical; the lateral corners of the segment rounded, and slightly produced posteriorly; the rostrum produced into well defined sharp point.

The abdomen 4-jointed, the segment and furca in the proportional lengths 40 : 16 : 15 : 11 : 18 = 100; the genital segment aymmetrical: the right side is slightly swollen, there is a protuberance on the ventral surface of the right side; the furcal rami 1.7-time as long as wide, the outermost seta is short, this is not figured by SARS.

The 1st antenna 24-jointed, reaches back to the distal margin of the 3rd abdominal segment. The 2nd antenna, mandible and maxilla as figured by SARS. The maxillipede has a transverse row of spinules on the posterior margin about the middle of the 1st basal joint as illustrated by A. SCOTT.

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the outer margin of the 1st has basal joint has groups of stiff hairs. The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the 2nd joint of the endopodite has two rows of spinules; the 1st basal joint is furnished with spinules; the terminal spine of the exopodite finely serrated. The 3rd leg has 3-jointed exopodite and endopodite; the 2nd and 3rd joints of the exopodite and endopodite are furnished with rows of spinules. The 4th leg has 3-jointed exopodite and endopodite; the 2nd and 3rd joints of the exopodite and endopodite are furnished with groups of spinules as shown in the figure; the 1st basal joint has a transverse row of long acicular spines on the posterior surface about the middle of the joint only on the left side; the acicular spines not extend beyond the distal margin of the 1st basal joint; the terminal spine of the exopodite is coarsely serrated.

Remarks. The present specimen agrees well with the description and figures given by several authors except that the head and 1st thoracic segment are separate.

Occurrence. Twenty five females in Sagami and Suruga Bay, from the depth 1000 m to the surface.

Distribution. The species has a wide distribution in the Atlantic, Pacific and Indian Oceans.

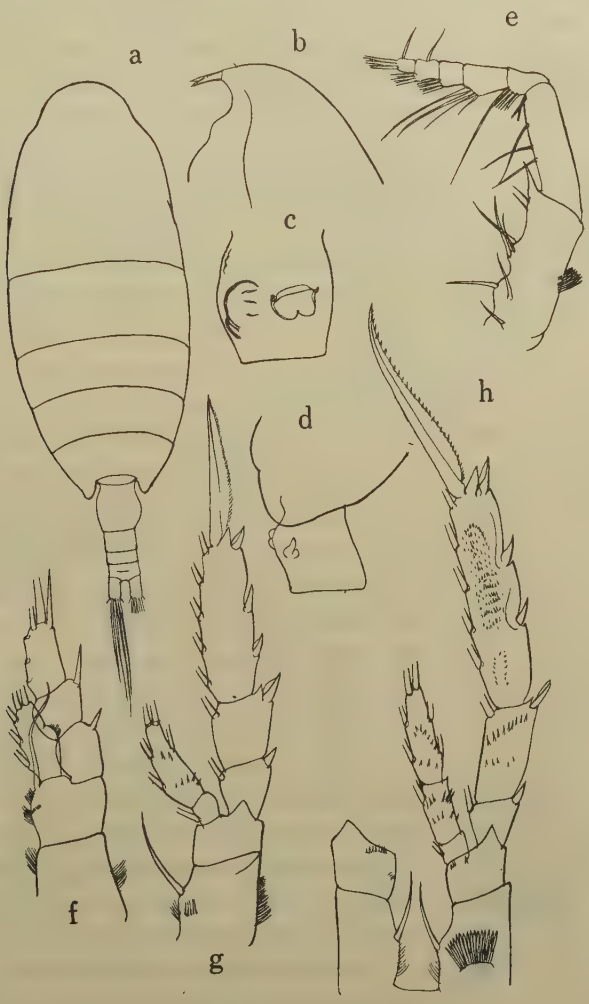


Fig. 18. *Monacilla typica* G. O. Sars.
a, Female: dorsal aspect; *b*, head, lateral aspect; *c*, genital, ventral aspect; *d*, last thoracic segment and genital segment, lateral aspect; *e*, maxillipede; *f*, 1st leg; *g*, 2nd leg; *h*, 4th legs.

Monacilla typica var. *asymmetrica*, var. nov.

(Fig. 19 *a*)

Fig. 19. *Monacilla typica* var. *asymmdtrica*, var. nov. *a*, Female: 4th legs.

Female. Length, 2.27 mm; cephalothorax, 1.77 mm; abdomen, 0.50 mm. The specimen agrees quite well with *M. typica* SARS except that there is a transverse row of short and slender acicular spines on the posterior surface of the 1st basal joint of the right 4th leg; the specimen may be referred to *M. gracilis* WOLFENDEN in having acicular spines on either side of the 1st basal joint of the 4th leg; but the shape of the genital segment differs from that of *M. gracilis*; the genital segment has a swelling on the right side as in *M. typica*, but the protuberance on the right side of the genital orfice is absent.

Occurrence. Two females from Sagami Bay in the vertical hauls from the depth 1000 m to the surface.

Monacilla gracilis (WOLFENDEN)

(Fig. 20, *a–c*)

Oxycalanus gracilis WOLFENDEN, 1911, p. 221.

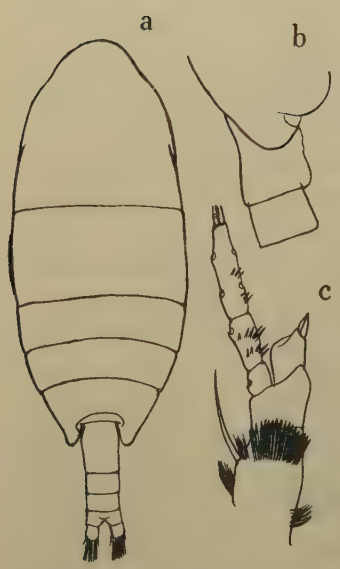


Fig. 20. *Monacilla gracilis* WOLFNDEN. *a*, Female: dorsal aspect; *b*, last thoracic segment and genital segment, lateral aspect; *c*, 4th leg.

Female. Length, 2.25 mm; cephalothorax, 1.75 mm; abdomen, 0.50 mm. The general appearance as in *M. typica*; the abdomen 4–segmented, the segments and furca in the proportional lengths 38 : 17 : 17 : 14 : 14 = 100; the genital segment symmetrical, not produced below as in *M. typica*; the furcal rami 1.3–times as long as wide.

The 1st antenna slightly exceeds the end of the furca when pressed against the body. The 2nd antenna has the exopodite as long as the endopodite. The mandible has the exopodite as long as the endopodite. The 1st maxilla has the following spinulation; the outer lobe, 9; the exopodite, 11; the endopodite, 6, 5, 4; the 2nd basal, 5; the 3rd inner lobe, 4; the 2nd inner lobe, 5; the 1st inner lobe, 14 setae. The 2nd maxilla and maxillipede have no interesting feature.

The 1st to 3rd swimming legs are as those of the foregoing species. The 4th pair of legs symmetrical; the transverse row of acicular spines exceeds

the distal margin of the 1st basal joint of the legs; the number of acicular spines about 18.

Remarks. The specimen, though larger in size, agrees fairly well with the WOLFENDEN's examples collected from the deep waters of the tropical Atlantic in Südpolar-Expedition. The species, though closely resembles *M. typica*, differs from it in the shape of the genital segment, and in having acicular spines on the 1st basal joint of the 4th pair of legs.

Occurrence. One adult female from Sagami in the vertical haul 1000 m to the surface, Nov., 1937.

Genus *Drepanopsis* WORFENDEN, 1911

The genus was created by WOLFENDEN. At present it comprises only one species, *Drepanopsis frigidus*, taken from the Antarctic region. The generic characters are as follows: head fused with the 1st thoracic segment; last two thoracic segments are separate; rostrum or rostral filments absent; 1st antenna 24-jointed, the joints are very setose; 2nd antenna with the endopodite longer than the exopodite; mandible with a small endopodite; 1st and 2nd maxillae and maxillipede are of *Paracalanus*-type; 1st to 4th legs as those of *Spinocalanus*, but the number of spines on the faces of the joints much reduced; 5th pair of legs 3-jointed, with two apical setae. The genus *Farrania* created by SARS is identical with *Drepanopsis* WOLFENDEN. The presence of four setae on the 3rd joint of the exopodite of the 2nd and 3rd legs indicate that the genus *Farrania* is not allied to the genus *Spinocalanus*, but to *Clausocalanus* or *Pseudocalanus*.

Drepanopsis frigidus WOLFENDEN

(Fig. 21, *a–k*)

Drepanopsis frigidus WOLFENDEN, 1911, p. 245; FARRAN, 1929, p. 232; SEWELL, 1929, p. 96; VERVOORT, 1951, p. 61, figs. 34–39.

Female. Length, 2.88–2.95 mm. The body oblong ovate in dorsal view. The head fused with the 1st thoracic segment, the 4th thoracic segment separates from the 5th; the lateral corners of the last thoracic segment produced triangularly, but the apex is not so sharp as figured by WOLFENDEN. The rostrum is represented by two small points when viewed from the ventral.

The abdomen 4-segmented and is contained about 6-times in the length of the cephalothorax; the segment and the furca in the proportions 42 : 8 : 8 : 13 : 29 = 100; the genital segment 1.4-times as wide as long, and produced considerably below; the first three segments are fringed with very minute teeth on the distal margin; the furcal rami 1.5-times as long as wide.

The 1st antenna 24-jointed, reaches back to the end of the 3rd abdominal segment;

the joints measured along the posterior margin are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15	16	17
	31	55	27	31	31	31	34	55	31	34	34	48	52	55	52	51

	18	19	20	21	22	23	24	25
	51	51	41	34	48	52	45	27 = 1000;

Fig. 21. *Drepanopsis frigidus* WOLFENDEN.
a, Female: dorsal aspect; *b*, head, lateral aspect; *c*, abdomen, dorsal aspect; *d*, last thoracic segment and genital segment, lateral aspect; *e*, rostrum, ventral aspect; *f*, 2nd antenna; *g*, mandible blade; *h*, 1st maxillia; *i*, 1st leg; *j*, 2nd leg; *k*, 4th leg.

the joints are furnished with slender setae. The 2nd antenna has the exopodite about as long as the endopodite; the 2nd joint of the exopodite has two protuberances which carry each a short marginal seta. The mandible has a small endopodite; the biting part is furnished with groups of fine spinules. The 1st maxilla has the following spinulation: the outer lobe has 9 setae, the exopodite 11 setae, the endopodite 4, 4, 6 setae. The 2nd maxilla has a row of spinules on the 2nd and 3rd lobe; the setae

arising from the endopodite are unmodified. The maxillipede as shown in the figure; the basal joints are furnished with rows of spinules on the anterior margin.

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the 1st basal joint has two groups of spinules on the outer margin. The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the 1st and 2nd joints of the endopodite are furnished with spinules on the posterior surface; the terminal spine of the exopodite has 29 serrations. The 3rd and 4th leg have each 3-jointed exopodite and endopodite; the joints of the endopodite are furnished with groups of spinules on the posterior surface; the terminal spine of the exopodite has 28 and 43 serrations respectively. The 5th pair of legs 3-jointed; the distal joint has two spines; the inner one is about as long as the combined lengths of the three joints taken together.

Remarks. The specimen agrees well with the description given by WOLFENDEN. FARRAN's specimen from the Antarctic has the total length 2.58–2.88 mm; SEWELL's specimen from the Indian Seas measured 2.28 mm, and has a backwardly pointing median spine instead of bifid rostrum. VERVOORT's specimen from the Antarctic measured 2.90 mm, and has a rostral median spine. The present specimen agrees quite well with those described except the stupid rostrum and longer abdomen and 1st antenna.

Drepanopsis orbus sp. nov.

(Fig. 22, *a–k*)

Female. Length, 3.56 mm; cephalothorax, 2.79 mm; abdomen, 0.77 mm; the cephalothorax elongate ovate; the head separates from the 1st thoracic segment; the 4th and 5th thoracic segments are incompletely separate; the lateral corners of the last thoracic segments are produced into sharp points; the rostrum absent.

The abdomen 4-jointed; the segments and furca in the proportions: 38:18:16:15:13=100; the genital segment as long as wide; the furcal rami as long as wide; the outer-marginal seta of the furca slender and short; the first three abdominal segments are furnished with fine spinules on the distal margin.

The 1st antenna 24-jointed, extends to the distal margin of the genital segment, the joints are in the following proportional lengths:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15	16	17
	58	81	38	35	38	35	36	55	32	32	35	46	49	49	49	49
	18	19	20	21	22	23	24	25								
	46	46	38	38	32	35	32	17 = 1000;								

the setae on the joints are slender as in *D. frigidus*. The 2nd antenna has the exopodite about as long as the endopodite (42:44); the 2nd joint of the exopodite has three prominences on the anterior margin, and they carry each a seta; the 1st basal has a row of hairs. The mandible as those of *D. frigidus*. The 1st maxilla has the

following spinulation on the various parts: the outer lobe has 7 long and 2 short setae; the exopodite is very small, carries 11 setae; the endopodite has 7, 5, 4 setae; the 2nd basal joint has 5 setae; the 3rd and 2nd inner lobe have each 4 setae; the 1st inner lobe has 14 setae. The 2nd maxilla as that of *D. frigidus*. The maxillipede robust, and in the main features resembles that of *D. frigidus*.

Fig. 22. *Drepanopsis orbus* sp. nov.
a, Female: dorsal aspect; *b*, head, lateral aspect; *c*, last thoracic segment and genital segment, lateral aspect; *d*, anal segment and furca, dorsal aspect; *e*, maxillipede; *f*, 1st leg; *g*, 2nd leg; *h*, endopodite of 4th leg; *i*, Male: last thoracic segment and genital segment; *j*, 5th pair of legs; *k*, terminal joint of right 5th leg.

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the joints of the endopodite slender; the outer-edge spines of the exopodite long, there is a small protuberance on the outer margin about one-third of the terminal joint of the exopodite; the 1st basal joint protuberates on the outer distal corner. The 2nd leg has

3-jointed exopodite and 2-jointed endopodite; the 1st basal joint is furnished with stiff hairs on the outer and also in the inner margin; the 2nd basal joint has a row of spines near the junction with the exopodite; the endopodite has a group of spines on the 1st joint, and three groups of spines on the 2nd joint; the terminal spine of the exopodite has 39 serrations. The 3rd leg has 3-jointed exopodite and endopodite, and has similar features as those of the 2nd leg; the terminal spine of the exopodite has 34 serrations. The 4th leg has 3-jointed exopodite and endopodite; there is no stiff hair on the outer margin of the 1st basal joint, and no row of spine on the 2nd basal joint; the endopodite is furnished with very minute spinules on the posterior surface; the terminal spine has 42 serrations. The 5th leg entirely absent.

Male. Length, 3.01 mm; cephalothorax, 2.30 mm, abdomen, 0.71 mm; the general appearance as in the female. The abdomen 5-segmented, the segments and fruca in the proportional lengths: 13 : 26 : 20 : 23 : 3 : 15 = 100: the furcal rami about 1.3-times as long as wide.

The 1st antenna 21-jointed, reaches back to the middle of the 2nd abdominal segment; the joints are in the following proportions:

Joint	1	2	3	4	5	6	7	8–9–10	11	12–13	14	15	16	17
	31	73	35	31	34	34	34	57	31	31	34	42	42	50	50	50
	18	12	20	21	22	23	24–25							
	50	54	46	56	42	50	38	15 = 1000;						

the joints 8–9–10, 12–13 and 24–25 are fused; the joints 20 and 21 are fused on the right side; the 3rd joint has a very long distal seta. The 2nd antenna as in the female, and bears three prominences on the 2nd joint of the exopodite. The mandible has a robust 2nd basal joint; the exopodite about as long as the endopodite (13 : 15). The 1st maxilla has a large endopodite bearing 10 setae; the endopodite reduced, has 11 setae; the 1st inner lobe much reduced. The 2nd maxilla reduced; the first three lobes are furnished with only poor setae. The maxillipede as in the female.

The 1st to 4th swimming legs as those of the female. The 5th pair of legs slender, consist of 2-jointed basal joint and 3-jointed exopodite and 1-jointed endopodite; the right leg is longer than the left, the distal joint of the right leg is furnished with hairs as shown in the figure.

Remarks. The specimen differs from *D. frigidus* in the segmentation of the cephalothorax, and in the absence of the 5th leg in the female. But in other respects the specimen is so closely allied to the genus *Drepanopsis* that I dare regard the present specimen as congenerous with *Drepanopsis.* The structure of the male 5th legs also indicates a close affinity to *Drepanopsis.*

Occurrence. Three females and one male in the vertical hauls from 1000 m to the surface in Sagami Bay.

Genus *Tanyrhinus* FARRAN, 1936

FARRAN created a new genus *Tanyrhinus* to accomodate a small Calanoida closely resembling to *Mimocalanus* FARRAN. The generic characters are as follows: the head and the first thoracic segment are separate; the 4th and the 5th thoracic segments are separate; the abdomen 4-jointed; the 1st antenna 23-jointed, the joints 8-9 and 24-25 being fused; the 2nd antenna as in *Mimocalanus*, with two setae on the inner margin of the 2nd joint of the exopodite; the mandible with a large two-branched palp; the endopodite longer than the exopodite; the maxilla as in *Mimocalanus* and *Spinocalanus*; the 2nd maxilla as in *Paracalanus*, except that the 4th lobe is longer than the 1st; the maxillipede is of *Mimocalanus* type, with well developed setae; the 1st and 2nd joints of the exopodite of the 1st leg without inner marginal seta, and the terminal joint of the endopodite of the 2nd to 4th legs have four inner marginal setae; the 5th leg absent.

The genus comprises only one species, *Tanyrhinus naso* FARRAN. Up to the present time no example of the genus has not been met with in the Izu region.

Ryocalanus TANAKA, 1956

Cephalothorax elongate; the head is separate from the 1st thoracic segment, and so are the 4th from the 5th; rostrum stout, one-jointed; the abdomen 5-jointed in the male; 1st antenna 24-jointed, the joints 8 and 9 are fused; in the male right antenna is transformed into a grasping organ, the joints 23 and 24 are fused, the hinge exists between the joints 22 and 23. 2nd antenna as in *Drepanopsis*, with three setae on the inner margin of the 2nd joint of the exopodite, the 1st basal joint has a brush of hairs in posterior aspect. Mandible with a slender palp, the endopodite 2-jointed, shorter than the exopodite. 1st maxilla as in *Mimocalanus*, but in the exopodite, 2nd basal joint and lobes are slender. 2nd maxilla as in *Pseudocalanus*, the 5th lobe is the largest. Maxillipede as in *Drepanopsis*, except that the distal two joints are furnished with well developed setae on the outer margin. 1st to 5th swimming legs as in *Spinocalanus* and *Monacilla*, except that the distal joint of the exopodite of the 1st leg has a spine on the outer margin about the middle of the joint. The 5th legs of the male as in *Pseudocalanus*.

Ryocalanns infelix TANAKA

Ryocalanus infelix TANAKA, 1956, p. 3, figs. 1 and 2.

Male. Length, 2.18 mm; cephalothorax, 1.93 mm, abdomen, 0.25 mm; the head separates from the 1st thoracic segment; the last two thoracic segments are separate; the cephalothorax elongate ovate, the head contracts anteriorly; the last thoracic segment produced into an acute spine on each side, directing ventrally; the ventral

margin of the segment is furnished with fine spinules; the rostrum one-pointed, and acute, there is, in lateral view, a notch on the posterior surface near the distal end.

The abdomen 5-jointed, the segments and the furca in the proportional lengths 32:18:11:7:14:18=100; the 1st abdominal segment about half as long as wide, and is furnised with fine spinules on the distal corner of the right side, the 2nd to 4th segments are fringed with spinules on the distal margin; the furcal rami wider than long, carries five setae, of which the outermost is short and slender, the dorsal surface of the rami furnished with minute spinules, the appendicular seta short.

The left 1st antenna broken off in the distal part, the joints 8–9 are incompletely fused on the anterior margin, the joints 1 to 15 are in the proportions:

Joint	1	2	3	4	5	6	7	8–9	10	11	12	13	14	15
	20	14	5	5	5	5	4	7	5	6	6	6	6	6

The right antenna forming a grasping organ, extends to the distal margin of the 2nd thoracic segment; the joints 8–9 are entirely fused, the joints 18 to 22 are inflated; each joint with a distal seta and an aesthetask on the anterior margin; joint 20 has a seta on the posterior margin, the joint 21 has fine denticles and a seta on the posterior margin; the joint 22 is highly chitinised on the posterior margin and has a short distal seta, the joint 23 and 24 are incompletely separate, and forms a comb-like projection furnished with 19 denticles on the posterior margin; there is a minute seta at the junction with the 24th joint; the 24th joint has also a distal seta on the anterior and posterior margins; the joint 25 has five setae and an aesthetask; the joints 12 to 19 are furnished with hairs on the posterior margin.

The 2nd antenna has the exopodite about as long as the endopodite; the exopodite 7-jointed, the joint 2 has three marginal setae; the distal joint of the endopodite has 8+6 setae. The mandible has the exopodite slightly longer than the endopodite; the exopdite 5-jointed; the endopodite 2-jointed, and has ten setas on the 2nd joint; the 2nd basal joint carries three setae; the cutting edge has eighe teeth. The 1st maxilla well developed; the outer lobe has four long and two short setae; the exopodite has 7+4+4, the 2nd basal five; the 3rd inner lobe four; the 2nd inner lobe five; the 1st inner lobe fourteen spines. The 2nd maxilla is of normal type; the 1st lobe has four setae, the 2nd to 5th have each three setae; the 6th lobe has two setae; of which the distal one is short; the endopodite has six setae; the 1st basal has an outer marginal seta. The maxillipede slender; the outer marginal seta on the 4th and the 5th joint of the endopodite long; the 2nd joint of the endopodite is the largest.

The 1st leg has 3-jointed exopodite and 1-jointed endopodite; the outer edge spine of the joints of the exopodite are long; the 3rd joint has four inner marginal setae, and two outer marginal spines; the distal half of the outer margin is hollowed; the endopodite has a process on the proximal outer margin; the 2nd basal joint has a row of spinules on the inner distal margin at the base of the endopodite; the exopodite of the right leg has an abnormal structure: the inner marginal setae on the

2nd and 3rd joint of the exopodite are converted into strong spines. The 2nd leg has 3-jointed exopodite and 2-jointed endopodite; the joints of the exopodite, especially the 2nd and the 3rd joints are densely covered with fine spinules on the posterior surface; the 3rd joint has five inner marginal setae; the posterior surface of the joints of endopodite are furnished with groups of spinules; the terminal spine of the exopodite has 23 teeth which are connected with a sort of thin lamella; the outer margin of the 2nd joint and the proximal section of the 3rd joint of the exopodite have, beside acicular spines, a row of slender and curved spines as shown in the figure; this arrangement of the spinules is observed also in the exopodite of the 3rd and 4th legs. The 3rd leg has 3-jointed exopodite and endopodite; the joints of the exopodite and endopodite are furnished with spinules as in the 2nd leg; the terminal spine of the exopodite has 25 teeth; the 3rd joint of the endopodite has six setae in all. The 4th leg has 3-jointed exopodite and endopodite; the structure as in the 3rd leg; the terminal spine of the exopodite is very finely serrated.

The 5th legs consist of five joints; the left leg much longer than the right; the terminal joint has two apical spines; the right leg has an outer edge spine on the 3rd joint; the terminal joint has two unequal apical spines.

Remarks: The specimen appears to be allied to *Autanepsis*, described by WOLFENDEN in the report of the "Süd-polar Expedition" in the structure of the swimming legs, but mouth parts are entirely different. The grasping antenna of the present specimen differs from those found in the tribe Heterarthrandria which has a movable articulation between the joints 18 and 19. The structure of the 1st to 4th legs resemble those of Pseudocalanidae, yet the peculiar structure in the grasping antenna has not, so far as I am aware, been reported, and I accommodate, at the present time, this curious specimen in the new genus under the name *Ryocalanus infelix* in memory of my only son who lost his life early in his boyhood. The description and figures of the species were published in "Breviora," Museum of Comparative Zoology of Harvard University, No. 64, October 11, 1956.

Occurrence. One adult male in the vertical haul from the depth 1410 m to the surface, in Suruga Bay, Nov., 1938.

MARINE CYANOPHYCEAE OF AMAMI-OSHIMA ISLAND

Isamu UMEZAKI
Department of Fisheries, Kyoto University, Maizuru

With One Table and 7 Text-figures

I. Introduction

In April 1955, the writer had an opportunity to work on the marine Cyanophyceae of Amami-Oshima island, main island of the Amami Islands which belong to the Prefecture of Kagoshima in Kyushu. The Amami Islands, a group of the Satsunan Islands stretching from lat. 27°N. to lat. 31°N., between Tanega-Shima and Yoron-Tô, lie in the southernmost part of the sea of Japan, under the present law, and consist mainly of five islands: Amami-Oshima (or Oshima), Kikai, Tokuno-Shima, Okinoerabu, and Yoron-Tô. Among these islands Amami-Oshima is the largest and is geographically situated between lat. 28° N. and lat. 28° 32′N. and between long. 129° 7′ E. and long. 129° 45′ E.

For many years past, the marine flora of Japan (including southern Saghalien, the Kuriles, the Loochoos and Formosa) has been rather precisely studied by many Japanese phycologists; and the whole aspect of the geographical distribution along the Japanese coasts has been made clear. The regret is that the Satsunan Islands including the Amami and Tokara Islands have not been visited by phycologists, to study the marine Cyanophyceae and other classes of algae, because of the inconvenience of communications and of other difficulties.

With the object of studying the marine Cyanophyceae the writer visited that island in April 1955, staying for twenty days. This study will contribute towards showing the flora of the marine Cyanophyceae of the island, thus giving a hint to solve phytogeographical problems of the Japanese marine flora. In 1955 the writer published a list of the marine Cyanophyceae of the Tokara Islands lying a little north of Amami-Oshima, and mentioned 21 species from there though the majority of them were cosmopolitan. Though the present study is treated on the basis of a smal collection which he got during his short trip, 7 families, 21 genera, 51 species were discovered there. In addition to the floristic study of the island this paper deals with ecological observation and the phytogeographical problems involved.

Publ. Seto Mar. Biol. Lab., V (3), 1956. (Article 24)

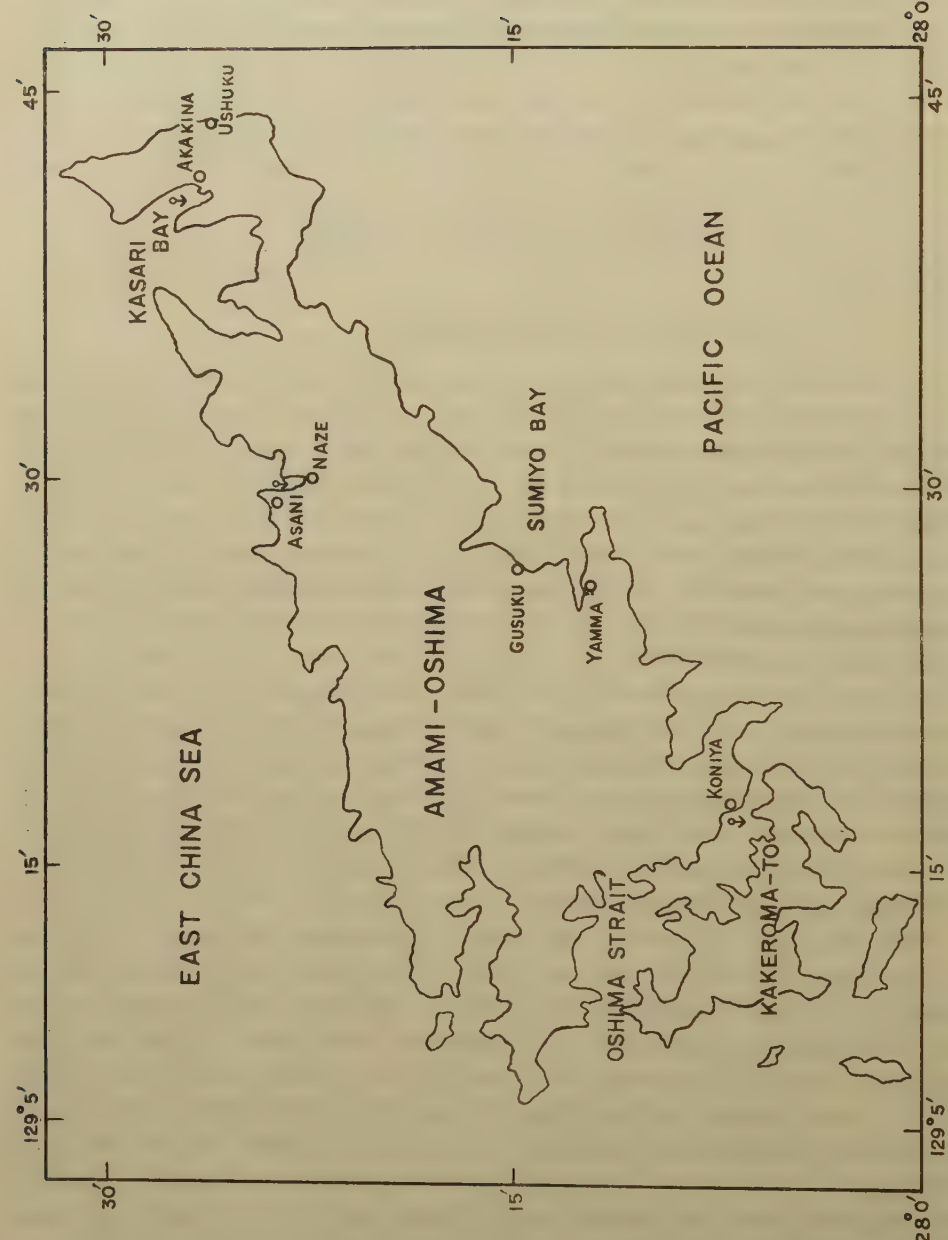


Fig. 1. Map showing the site of collecting stations in Amami-Oshima island.

II. Brief Note on the Collecting Stations

It is needless to say that for the study of the algal flora of a certain district it is necessary to visit there several times, staying there as long as possible. The period of the present collector's stay there, however, was short — only twenty days —, and the stations he visited were restricted to only seven regions: Naze, Asani, Akakina, Ushuku, Yamma, Gusuku, and Koniya, as is shown in Fig. 1. Fortunately, all of the localities visited were convenient for him to investigate the conditions of the growth of the algae. Still more fortunately, while he stayed in the island it was just spring-tide at full moon. All the material was collected by wading on rocks in the intertidal belt during two or three hours at low tide after the tide was turned. The following is the general description of the stations visited and the general appearance of the algal growth at each station.

1. Naze Station: The west coast of Naze Port (about 2,500 meters in distance from Naze street to Yagi-Jima) is a good locality for collecting the algae, and the coast is of sand and of huge or small rocks. This region is also just suitable for collecting them within two or three hours at one tide.

2. Asani Station: The shallow coast of Asani which is located at about 2,500 meters west of Naze town is a monotonous zone composed of coral reefs and small pebbles. On rocks in the upper littoral zone a number of the fronds of *Symploca hydnoides*, whose occurrence is conspicuous at this station, were found. The flora of the marine algae of other classes than the blue-green algae was scanty.

3. Akakina Station: The eastern coast of Akakina which forms the Akakina Port of Kasari Bay resembles that of Asani. The algal growth along this coast was also scanty. But *Calothrix pilosa* and *Rivularia polyotis* were luxuriant here.

4. Ushuku Station: The coast of Ushuku, Kasari-mura (about 4,000 meters east of Akakina), is a good locality for collecting the marine algae because at low tide it extends to about 200 meters off the shore, where there are flat rocks with many small tide pools or rock depressions. The green and red algae, not the blue-green algae, were plentiful; and on shaded rocks in tide pools there were growing a number of the large tufts of *Chamaedoris orientaris*, a green alga. The large plants of *Anacystis aeruginosa* were abundantly found growing on rocks in the upper littoral zone.

5. Gusuku Station: Gusuku in Sumiyo Bay is just at the middle region between Naze and Koniya, and the coast line consists of both sandy and rocky beaches where rocks are comparatively large. When the waves are high, collecting the materials is very difficult or almost impossible. The alga *Brachytrichia Quoyi* showed plentiful growth in the lower littoral zone where it entirely covered rocks and coloured the surface deep blue-green or dark green. The blackish-violet fronds of *Oscillatoria nigro-viridis* were abundantly found covering the surface of rocks in the upper littoral zone.

6. Yamma Station: Yamma, which lies along the southern shore of Sumiyo Bay where a large wood of mangrove trees is luxuriant, is very poor regarding the marine

algae of other classes, except for abundant growths of *Ulva pertusa* and *Nemalion pulvinatum*. Cyanophyceae, on the other hand, were rather plentiful as compared with other groups of algae.

7. Koniya Station: Koniya (the largest port and town next to Naze) is at the southernmost end of the island. For collecting the materials the coast is very convenient because of having a widely extended rocky coastal line here and there, and luxuriant growths of the blue-green algae as well as algae of other classes were found. Especially Tean, about 4,000 meters west of Koniya and Seisui, 3,000 meters east of the Koniya, are the excellent localities in this vicinity. At Tean, *Gardnerula corymbosa*, *Rivularia polyotis*, and *Calothrix pilosa* were found in great abundance; while at Seisui, plentiful growths of *Hormothamnion enteromorphoides*, *Scytonema polycystum*, and *Lyngbya confervoides* were found. On the coast of both Tean and Seisui several species of *Caulerpa*, a green alga, grew abundantly on sands about one meter below low tide level. Among the above-mentioned stations, this region was the most luxuriant floristically.

III. Composition of the Species in Each Station

The following is a list showing the composition of the Cyanophycean vegetation in each station. As is shown in the list, Koniya, where two-thirds of the all listed species were collected, was the best station in regard to the floristic composition; while Naze, Akakina, and Ushuku were poor, although Ushuku was a good station for marine algae of other classes than the blue-green algae. Especially noteworthy species for the Japanese flora, *Gardnerula corymbosa*, *Fremyella vitiensis*, *Scytonema polycystum*, and *Hormothamnion enteromorphoides* were found only in the Koniya coast. *Rivularia polyotis* and *Calothrix pilosa* were collected at both Akakina and Koniya. *Symploca hydnoides* was found on the coasts of Naze, Asani, and Gusuku. *Brachytrichia maculans* was obtained from all other stations excepting Ushuku, and *B. Quoyi* from the five stations other than Yamma and Ushuku. All of the species belonging to Chamaesiphonaceae, Stigonemataceae, Scytonemataceae, and Nostocaceae were discovered at the Koniya station. Among these species listed, especially *Entophysalis conferta*, *Calothrix crustacea*, *Brachytrichia maculans*, *B. Quoyi*, *Microcoleus tenerrimus*, *M. chthonoplastes*, *Hydrocoleum lyngbyaceum*, and *H. cantharidosmum*, were rather widely and comparatively abundantly distributed on this island. *Oscillatoria chalybea* and *O. Bonnemaisonii* were quite rarely and scarcely encountered only at Koniya. Among 51 species in all, 9 were recorded from Naze, 10 from Akakina and Ushuku, 13 from Gusuku, 19 from Asani, 20 from Yamma, and 38 from Koniya.

1. Naze Station: *Entophysalis conferta*, *Calothrix crustacea*, *Brachytrichia muculans*, *B. Quoyi*, *Oscillatoria nigro-viridis*, *Lyngbya semiplena*, *Microcoleus chthonoplastes*, *Hydrocoleum glutinosum*, and *Symploca hydnoides*.

2. Asani Station: *Entophysalis conferta*, *E. deusta*, *Calothrix aeruginea*, *C. crustacea*, *Brachytrichia maculans*, *B. Quoyi*, *Mastigocoleus testarum*, *Plectonema terebrans*,

P. norvegicum, *Oscillatoria nigro-viridis*, *Phormidium epiphyticum*, *Lyngbya infixa*, *L. gracilis*, *L. confervoides*, *Microcoleus tenerrimus*, *M. chthonoplastes*, *Hydrocoleum cantharidosmum*, *H. coccineum*, and *Symploca hydnoides*.

3. Akakina Station: *Calothrix balearica*, *C. crustacea*, *C. pilosa*, *Rivularia polyotis*, *Brachytrichia maculans*, *B. Quoyi*, *Lyngbya semiplena*, *Microcoleus tenerrimus*, *M. chthonoplastes*, and *Hydrocoleum lyngbyaceum*.

4. Ushuku Station: *Anacystis aeruginosa*, *Entophysalis conferta*, *Mastigocoleus testarum*, *Plectonema terebrans*, *Spirulina tenerrima*, *Phormidium epiphyticum*, *Lyngbya sordida*, *Microcoleus chthonoplastes*, *Hydrocoleum lyngbyaceum*, and *H. coccineum*.

5. Gusuku Station: *Calothrix aeruginea*, *C. crustacea*, *Brachytrichia maculans*, *B. Quoyi*, *Plectonema norvegicum*, *P. calothrichoides*, *Oscillatoria nigro-viridis*, *Lyngbya Nordgardhii*, *Microcoleus Vaukii*, *Hydrocoleum lyngbyaceum*, *H. cantharidosmum*, *H. coccineum*, and *Symploca hydnoides*.

6. Yamma Station: *Coccochloris stagnina*, *Entophysalis conferta*, *E. deusta*, *Calothrix aeruginea*, *C. scopulorum*, *C. balearica*, *C. crustacea*, *Brachytrichia maculans*, *Plectonema norvegicum*, *P. calothrichoides*, *P. Nostocorum*, *Spirulina tenerrima*, *Oscillatoria nigro-viridis*, *Phormidium Corium*, *P. epiphyticum*, *Lyngbya semiplena*, *L. lutea*, *Microcoleus tenerrimus*, *Hydrocoleum lyngbyaceum*, and *H. glutinosum*.

7. Koniya Station: *Anacystis dimidiata*, *A. aeruginosa*, *Agmenellum thermale*, *Entophysalis conferta*, *E. deusta*, *Calothrix parasitica*, *C. aeruginea*, *C. scopulorum*, *C. confervicola*, *C. pilosa*, *C. crustacea*, *Isactis plana*, *Gardnerula corymbosa*, *Rivularia atra*, *R. polyotis*, *Brachytrichia maculans*, *B. Quoyi*, *Mastigocoleus testarum*, *Fremyella vitiensis*, *Scytonema polycystum*, *Hormothamnion enteromorphoides*, *Oscillatoria Bonnemaisonii*, *O. chalybea*, *Phormidium Corium*, *Lyngbya Rivulariarum*, *L. gracilis*, *L. sordida*, *L. semiplena*, *L. majuscula*, *L. confervoides*, *L. lutea*, *L. aestuarii*, *Microcoleus tenerrimus*, *M. chthonoplastes*, *Hydrocoleum lyngbyaceum*, *H. cantharidosmum*, *H. glutinosum*, and *H. coccineum*.

IV. Ecological Observations

In habit the marine blue-green algae show greater variations than any class of marine algae, some species being found epiphytic on larger algae, some endophytic in other algae, some planktonic, some on rocks, some in limestone or shells, and so on. From the viewpoint of habit the writer has classified into five forms: (1) planktonic form; (2) lithophytic form; (3) epiphytic form; (4) endophytic form; and (5) shell-perforating form.

The species such as *Anacystis dimidiata* and *Agmenellum thermale* come under the category of the planktonic form, although these species were found floating among the filaments of other algae, not being planktonic in the water. Most of the species here recorded, especially those of Rivulariaceae, were abundantly found on rocks in intertidal belt where they formed conspicuous growths. *Calothrix scopurolum*, *C. crustacea*, *Isactis plana*, *Gardnerula corymbosa*, *Rivularia atra*, *R. polyotis*, *Brachytri-*

Table 1. A list of the Cyanophycean species of Amami-Oshima island and an outline of their geographical distribution in the world.

Species \ Locality	Japan: Honshu	Japan: Hokkaido	China	Southeast Asia	Warmer Pacific Ocean	Pacific coast of North America	West Indies	Australia	Europe	Cosmopolitan or probably cosmopolitan	Freshwater species
Chroococcaceae											
1. *Coccochloris stagnina* SPRENGEL	+	−	−	−	−	+	+	+	+	+	+
2. *Anacystis dimidiata* (KG.) DR. & DAILY	+	−	−	−	+	+	+	−	+	+	+
3. *A. aeruginosa* (ZANARD.) DR. & DAILY	+	−	−	−	−	+	+	−	+	−	−
4. *Agmenellum thermale* (KG.) DR. & DAILY	+	+	−	+	+	+	+	−	+	+	+
Chamaesiphonaceae											
5. *Entophysalis conferta* (KG.) DR. & DAILY	+	+	−	+	+	+	+	+	+	+	−
6. *E. deusta* (MENEGH.) DR. & DAILY	+	+	−	−	+	+	+	+	+	+	−
Rivulariaceae											
7. *Calothrix parasitica* (CHAUV.) THUR.	+	+	−	−	+	+	−	−	+	+	−
8. *C. aeruginea* (KG.) THUR.	+	−	−	+	+	+	+	+	+	+	−
9. *C. balearica* BORN. & THUR.	+	−	−	−	−	−	−	−	+	−	+
10. *C. scopulorum* (W. & M.) AG.	+	+	−	+	+	+	+	+	+	+	−
11. *C. confervicola* (ROTH) AG.	+	+	−	−	−	+	+	+	+	+	−
12. *C. crustacea* THUR.	+	+	−	+	+	+	+	+	+	+	−
13. *C. pilosa* HARV.	+	−	−	+	+	+	+	−	−	−	−
14. *Isactis plana* (HARV.) THUR.	+	+	−	−	+	+	+	+	+	−	−
15. *Gardnerula corymbosa* (HARV.) J. DE TONI	+	−	−	−	+	−	+	−	+	−	−
16. *Rivularia atra* ROTH	+	+	−	−	−	+	−	+	+	+	−
17. *R. polyotis* (AG.) BORN. & FLAH.	−	−	−	−	−	−	−	+	+	−	−
Stigonemataceae											
18. *Brachytrichia maculans* GOM.	+	+	+	+	+	−	−	−	−	−	−
19. *B. Quoyi* (AG.) BORN. & FLAH.	+	+	+	+	+	+	+	+	−	−	−
20. *Mastigocoleus testarum* LAGERH.	+	+	−	−	+	+	+	−	+	−	−
Scytonemataceae											
21. *Fremyella vitiensis* (ASK.) J. DE TONI	−	−	−	−	+	+	+	−	−	−	−
22. *Scytonema polycystum* BORN. & FLAH.	−	−	−	−	+	−	−	−	−	−	−
Nostocaceae											
23. *Hormothamnion enteromorphoides* GRUNOW	−	−	−	+	+	−	+	−	−	−	−
Oscillatoriaceae											
24. *Spirulina tenerrima* KUETZ.	−	−	−	−	+	−	−	−	+	+	+
25. *Oscillatoria Bonnemaisonii* GROUAN	+	−	−	−	+	+	+	−	+	+	−
26. *O. chalybea* MERTENS	+	+	−	−	−	+	+	−	+	+	+
27. *O. nigro-viridis* THWAITES	+	−	−	+	+	+	+	−	+	+	−
28. *Plectonema terebrans* BORN. & FLAH.	+	−	−	−	+	+	−	−	+	+	−
29. *P. calothrichoides* GOM.	−	+	−	−	−	+	−	−	+	−	−
30. *P. norvegicum* GOM.	−	−	−	−	−	−	−	+	+	−	−
31. *P. Nostocorum* BORN.	−	−	−	−	+	−	−	−	+	+	+
32. *Phormidium Corium* (AG.) GOM.	+	+	−	+	−	+	+	−	+	+	+
33. *P. epiphyticum* GARDN.	+	+	−	−	−	+	+	−	−	−	−
34. *Lyngbya Rivulariarum* GOM.	+	−	−	−	+	−	−	−	+	+	+
35. *L. infixa* FRÉMY	+	+	−	−	−	−	+	−	+	−	−
36. *L. Nordgardhii* WILLE	+	+	−	−	−	+	+	−	+	−	−
37. *L. gracilis* RABENH.	+	−	−	−	−	+	+	−	+	−	−
38. *L. sordida* (ZANARD.) GOM.	+	−	−	−	−	−	+	+	+	−	−
39. *L. majuscula* HARV.	+	−	−	+	+	+	+	+	+	+	−
40. *L. confervoides* C. AG.	+	−	−	+	+	+	+	+	+	+	−
41. *L. semiplena* (C. AG.) J. AG.	+	+	−	−	+	+	+	+	+	+	−
42. *L. lutea* (AG.) GOM.	+	+	−	−	−	+	+	+	+	+	−
43. *L. aestuarii* (MERT.) LIEBM.	+	+	−	+	+	+	+	−	+	+	+
44. *Microcoleus tenerrimus* GOM.	+	+	−	−	+	+	+	−	+	+	−
45. *M. chthonoplastes* THUR.	+	−	−	−	−	+	+	−	+	+	−
46. *M. Voukii* FRÉMY	+	−	−	−	−	−	−	−	+	−	−
47. *Hydrocoleum lyngbyaceum* KUETZ.	+	+	−	+	+	+	+	+	+	+	−
48. *H. cantharidosmum* (MONT.) GOM.	+	+	−	+	+	−	+	+	−	−	−
49. *H. glutinosum* (AG.) GOM.	+	−	−	−	+	+	+	+	+	+	−
50. *H. coccineum* GOM.	+	−	−	−	+	+	−	−	+	−	−
51. *Symploca hydnoides* KUETZ.	−	−	−	+	+	+	+	+	+	+	−
Total	42	24	2	17	34	37	37	21	43	29	11

chia maculans, *B. Quoyi*, and *Symploca hydnoides* grew in solitary fashion, not associating with one another; while *Microcoleus tenerrimus*, *M. chthonoplastes*, and *Hydrocoleum lyngbyaceum*, associated with other algae or with one another, sometimes formed intricate fronds or *Phormidium*-like sheets on rocks. The former group which grew on rocks in littoral zone may be the true lithophytic form. The epiphytic form, which grows attached to algae of other classes or even on filamentous Cyanophyceae, were also abundantly discovered. In habit, two types of *Hormothamnion enteromorphoides* were observed, one growing on large algae such as *Hypnea cervicornis* and *Sargassum* sp. when young, the another floating freely when aged. The cortical tissues of *Nemalion* and *Codium* seem to be suitable for growth of some Cyanophyceae. Four species, *Calothrix parasitica*, *Lyngbya Rivulariarum*, *Microcoleus Voukii*, and *Hydrocoleum coccineum* are the endophytic form here. The study of algae not only Cyanophyceae but Chlorophyceae and Rhodophyceae boring into limestone or shells seems to be very interesting both taxonomically and ecologically. Three species were found associating with one another in mollusc shells.

The following is a list of the species classified into 5 forms.

1. Planktonic Form: *Coccochloris stagnina*, *Anacystis dimidiata*, *Agmenellum thermale*, *Oscillatoria chalybea*, and *O. Bonnemaisonii*.

2. Lithophytic Form: *Anacystis aeruginosa*, *Entophysalis deusta*, *Calothrix scopulorum*, *C. balearica*, *C. crustacea*, *C. pilosa*, *Isactis plana*, *Gardnerula corymbosa*, *Rivularia atra*, *R. polyotis*, *Brachytrichia muculans*, *B. Quoyi*, *Scytonema polycystum*, *Oscillatoria nigro-viridis*, *Phormidium Corium*, *Lyngbya majuscula*, *L. confervoides*, *L. semiplena*, *L. lutea*, *L. aestuarii*, *Microcoleus tenerrimus*, *M. chthonoplastes*, *Hydrocoleum lyngbyaceum*, *H. cantharidosmum*, and *Symploca hydnoides*.

3. Epiphytic Form: *Entophysalis conferta*, *Calothrix aeruginea*, *C. confervicola*, *Fremyella vitiensis*, *Hormothamnion enteromorphoides*, *Spirulina tenerrima*, *Plectonema norvegicum*, *P. calothrichoides*, *P. Nostocorum*, *Phormidium epiphyticum*, *Lyngbya infixa*, *L. Nordgardhii*, *L. gracilis*, and *L. sordida*.

4. Endophytic Form: *Calothrix parasitica*, *Lyngbya Rivulariarum*, *Microcoleus Voukii*, and *Hydrocoleum coccineum*.

5. Shell-perforating Form: *Entophysalis deusta*, *Mastigocoleus testarum*, and *Plectonema terebrans*.

V. On the Geographical Distribution

Table 1 shows a list of the Cyanophycean species from Amami-Oshima island and an outline of their geographical distribution. As compared with the marine algae of other classes, the bulk of the marine blue-green algae are cosmopolitan in their geographical distribution, with the exception of some conspicuous species. 29 cosmopolitan or probably cosmopolitan species were found. Among the total of 51 species here enumerated, 42 have already been recorded from Honshu (Umezaki 1950–56 a, 1955 a), 25 from Hokkaido (Umezaki 1956 b), 2 from the China coast (Tseng 1936,

1940), 17 from Southeast Asia (DAWSON 1954; GOMONT 1901), 34 from the warmer Pacific (DROUET 1936; MAY 1953; NIEL 1930; SETCHELL 1926; TAYLOR 1945, 1950; TILDEN 1910; WEBER-VAN BOSSE 1913, 1926), 37 from the Pacific coast of North America (JAO 1948; GARDNER 1918; SETCHELL and GARDNER 1903, 1919, 1924), 37 from the West Indies (FRÉMY 1939, 1941; GARDNER 1932; TAYLOR 1942; TILDEN 1910), 21 from Australia (GUILER 1952; WOMERSLEY 1946, 1950), and 43 from throughout Europe including the Mediterranean, the Adriatic sea and the British Isles (BATTERS 1902; BORNET & FLAHAULT 1886–88; FELDMANN 1937; FRÉMY 1934; GOMONT 1892, 1899; GEITLER 1932; LINDSTEDT 1943; MOELDER 1945; NEWTON 1931). 11 species which are known to occur in general habitats in fresh water were discovered on this Amami-Oshima, although they occasionally occur in marine water. The following seven species, *Rivularia polyotis*, *Fremyella vitiensis*, *Scytonema polycystum*, *Hormothamnion enteromorphoides*, *Plectonema norvegicum*, *P. Nostocorum*, and *Symploca hydnoides* have not yet been known from Honshu and Hokkaido, being new to Japan. Among of them, *Plectonema norvegicum* is known from arctic and north temperate regions and *Symploca hydnoides* is cosmopolitan in its geographical distribution. From the viewpoint of geographical distribution, the following four species, *Gardnerula corymbosa*, *Fremyella vitiensis*, *Scytonema polycystum*, and *Hormothamnion enteromorphoides*, are considered to be of tropical origin rather than of subtropical origin. Among them, *Gardnerula corymbosa*, however, was collected by the writer himself (1956 c) in November 1951 on the Shirahama coast of Honshu, where the alga was rather dwarf, having a length of 150–1300μ, and very rare in occurrence, undoubtedly because of the desirability of lower temperatures of water for growth. As far as the writer knows, Bermuda in the Atlantic Ocean seems to be a northernmost station for the species in the Atlantic Ocean, and Shirahama may be its northernmost region in the Pacific Ocean. From the floristic point of view the writer came to the conclusion that the marine Cyanophycean composition of Amami-Oshima island is subtropical, and he found that for the abundance of its flora the island is in good condition.

VI. Enumeration of Species

The systematic arrangement of the classification here adopted is that proposed by DROUET (1951), and the classification for Chroccoccaceae and Chamaesiphonaceae is that of DROUET & DAILY (1956), that for Rivulariaceae, Stigonemataceae, Scytonemataceae and Nostocaceae that of BORNET & FLAHAULT (1886–88), and that for Oscillatoriaceae that of GOMONT (1892), unless otherwise indicated. All of these specimens are kept in the writer's herbarium.

Division CYANOPHYTA

Family Chroococcaceae

Coccochloris stagnina SPRENGEL

Yamma: On rocks in the upper littoral zone, with other Cyanophyceae (Herb. Umez. 1747 in part).

Geogr. Distrib.: Cosmopolitan.

Anacystis dimidiata (Kuetzing) Drouet & Daily

Koniya: Among the filaments of *Lyngbya* sp. and *Hydrocoleum cantharidosmum* (1869 in part); among the fronds of *Hydrocoleum lyngbyaceum* (1803 in part); among the filaments of *Calothrix pilosa* (1808 b); among the masses of *Lyngbya aestuarii* (1784 b).

Geogr. Distrib.: Cosmopolitan.

Anacystis aeruginosa (Zanardini) Drouet & Daily

Koniya: Among the fronds of other filamentous Cyanophyceae (1769 in part). Ushuku: On rocks along high tide level (1857 b).

These local specimens are quite similar to illustrations of *Aphanocapsa sesciacensis* by Frey.

Geogr. Distrib.: Japan, North America, West Indies, Europe.

Agmenellum thermale (Kuetzing) Drouet & Daily

Koniya: Floating among other Cyanophyceae (1802 in part).

The plant resembles illustrations of *Merismopoedia elegans* of A. Braun.

Geogr. Distrib.: Cosmopolitan.

Family Chamaesiphonaceae

Entophysalis conferta (Kuetzing) Drouet & Daily

Koniya: On *Lyngbya aestuarii* (1756 in part). Asani: On *Bostrychia binderi* (1700); on *Calothrix aeruginea* (1701 in part); on *Calothrix crustacea* (1695 in part); on *Gelidium* sp. (1707); on *Caulacanthus* sp. (1709). Naze: On *Lyngbya semiplena* (1840 b); on *Caulacanthus* sp. (1842 b). Yamma: On *Lyngbya semiplena* (1736 in part, 1742 in part).

Various forms which have been in general described as *Chlorogloea conferta*, *Dermocarpa sphaerica*, *D. Marchantae*, *D. Leibleiniae*, *D. protea*, and *Dermocarpella hemisphaerica* are here referred to under the specific name *Entophysalis conferta*.

Geogr. Distrib.: Cosmopolitan.

Entophysalis deusta (Meneghini) Drouet & Daily

Asani: On *Brachytrichia maculans* (1699 in part). Koniya: On rocks and *Brachytrichia maculans* (1752 in part); perforating in a dead mollusc shell with

Mastigocoleus testarum (1839 b). Yamma: With *Hydrocoleum lyngbyaceum* on rocks in the upper littoral zone (1747 in part).

Geogr. Distrib.: Cosmopolitan.

Family Rivulariaceae

Calothrix parasitica (CHAUVIN) THURET

Koniya: In *Nemalion pulvinatum* (1778 in part).

Geogr. Distrib.: Japan, Pacific Ocean, North America, Europe, North Africa.

Calothrix aeruginea (KUETZING) THURET

Asani: On *Gelidium* sp. (1701 in part). Gusuku: On *Gelidium* sp. and *Nemalion pulvinatum* (1721 in part, 1722 in part). Koniya: On *Liagora* sp. (1810).

Geogr. Distrib.: Cosmpolitan.

Calothrix scopulorum (WEBER & MOHR) AGARDH

Yamma: On rocks in the upper littoral zone (1746 in part). Koniya: On rocks and living mollusc shells in the upper or lower littoral zone (1759, 1785 b, 1788 a).

Geogr. Distrib.: Cosmopolitan.

Calothrix confervicola (ROTH) AGARDH

Koniya: With *Fremyella vitiensis* on *Laurencia* sp. (1782 b).

Geogr. Distrib.: Cosmopolitan.

Calothrix balearica BORNET & FLAHAULT

Yamma: On vertical concrete along high tide level (1735 in part). Akakina: On *Hypnea* sp. in the upper littoral zone (1868).

Geogr. Distrib.: Europe.

Calothrix crustacea THURET

Asani: On rocks in a small rock depression in the upper littoral zone (1695 in part, 1698 a). Gusuku: On rocks in a rock depression a little above high tide level (1725 in part, 1729 a, 1730 in part). Yamma: On rocks and vertical concrete along high tide level (1735 in part, 1746 in part). Koniya; In association with *Lyngbya semiplena* on rocks in the upper littoral zone (1790 a, 1794 a, 1818). Naze: On rocks along high tide level (1853 a). Akakina: On rocks in the lower littoral zone (1864 b, 1867 b).

Geogr. Distrib.: Cosmopolitan.

Calothrix pilosa Harvey

Koniya: On rocks along high tide level or in the upper littoral zone (1753 a, 1807 a, 1808 a). Akakina: On rocks along high tide level (1870 b).

Geogr. Distrib.: Japan, Pacific Ocean, Southern Asia, North America, West Indies.

Isactis plana (Harvey) Thuret

Koniya: On rocks and living mollusc shells (1761, 1785 c, 1788 b).

This local plant belongs to var. *plana*.

Geogr. Distrib.: Japan, Pacific Ocean, North America, West Indies, Australia, Europe, North Africa.

Gardnerula corymbosa (Harvey) J. de Toni

Koniya: On rocks in the upper littoral zone or along high tide livel (1787, 1798 b, 1799, 1800, 1801, 1802).

Geogr. Distrib.: Japan, North America, Atlantic Ocean, South Asia, Mediterranean, West Indies.

Rivularia atra Roth

Koniya: On rocks along high tide level or a little below low tide level (1776, 1793, 1838 c).

Geogr. Distrib.: Cosmopolitan.

Rivularia polyotis (Agardh) Bornet & Flahault

(Fig. 2)

Koniya: On rocks in the upper littoral zone (1796 a). Akakina: On rocks along high tide level (1870 a).

Fronds light or dark olive green, soft, up

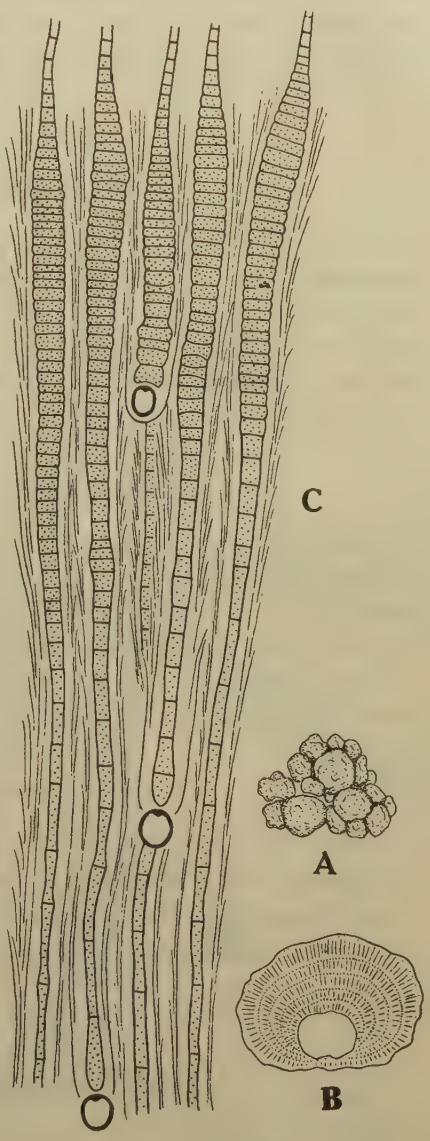


Fig. 2. *Rivularia polyotis* (Agardh) Bornet & Flahault.
A, habit of fronds, ×⅔. B, vertical section of a frond. ×4. C, part of the vertical section of a frond. ×350.

to 1 cm long or mostly confluent with one another; filaments readily separable under pressure; sheaths thick, colourless or light brown; trichomes 8.5–12μ broad in merismatic region, 2.5–5μ broad near heterocysts; cells in merismatic region 3–9μ long, below 12–30 (40)μ long; basal heterocysts 9–18μ broad.

Geogr. Distrib.: North America, Australia, Europe.

Family Stigonemataceae

Brachytrichia maculans GOMONT

Asani: On rocks in the upper littoral zone (1697, 1699 in part). Yamma: On rocks along high tide level (1740, 1747 in part). Koniya: On rocks in the upper littoral zone (1752 in part, 1774, 1777 in part, 1797 b). Naze: On rocks near high tide level (1854). Akakina: On rocks along high tide level (1864 a, 1867 a). Gusuku: On rocks in the upper littoral zone (1719, 1725 in part).

Geogr. Distrib.: Japan, China, Southern Asia, Pacific Ocean.

Brachytrichia Quoyi (AGARDH) BORNET & FLAHAULT

Asani: On rocks in the upper littoral zone (1703). Gusuku: On rocks in the lower littoral zone (1724). Koniya: On rocks in the upper littoral zone or the lower littoral zone (1768, 1804). Naze: On rocks along high tide level (1852). Akakina: On rocks in the upper littoral zone (1871 a).

Geogr. Distrib.: Japan, Southern Asia, China, Pacific Ocean, North America, West Indies, Australia.

Mastigocoleus testarum LAGERHEIM

Asani: In company with *Plectonema terebrans* in oyster shells (1712 a). Ushuku: In company with *Plectonema terebrans* in a mollusc shell (1876 a). Koniya: In oyster shells and in a dead mollusc shell (1782 c, 1839 a).

Geogr. Distrib.: Japan, Europe, North America, Pacific Ocean, West Indies.

Family Scytonemataceae

Fremyella vitiensis (ASKENACY) J. DE TONI

(Fig. 3)

Koniya: On *Laurencia* sp. with *Calothrix confervicola* (1782 a).

Filaments up to 600μ long, 7–9.2μ broad at the middle; sheaths colourless, thin; trichomes light blue-green, sometimes slightly tapering above, 5(4.5)–6.1μ broad at the middle, not constricted at the cross walls, rarely slightly constricted above; cells 2.5–6(9)μ long; heterocysts basal, usually single, hemisphaerical.

Geogr. Distrib.: Pacific Ocean, North Africa, North America, West Indies.

Scytonema polycystum Bornet & Flahault

(Fig. 4)

Koniya: On rocks in the upper littoral zone (1758 a); on rocks and on *Bostrychia binderi* (1791).

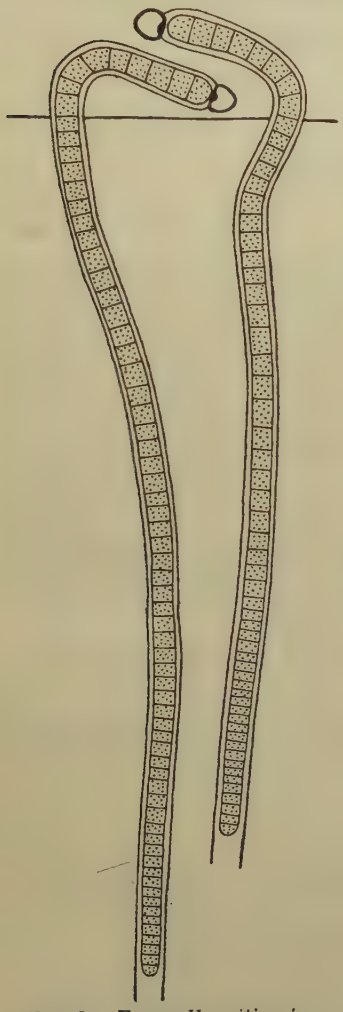


Fig. 3. *Fremyella vitiensis* (Askenacy) J. de Toni. Two filaments. ×350.

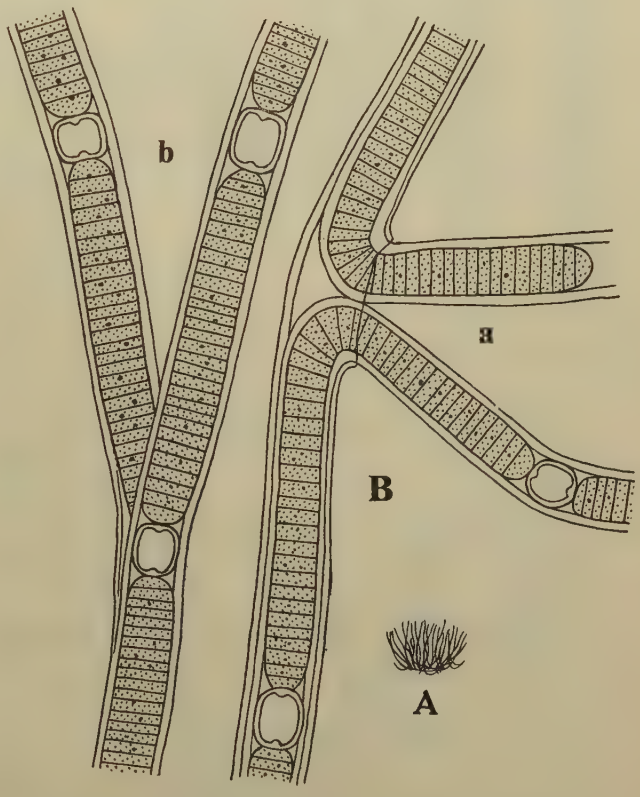


Fig. 4. *Scytonema polycystum* Bornet & Flahault. A, habit of filaments. ×½. B, two portions of filaments showing geminate- (a) and single-branching (b). ×250.

Plant mass 1 cm broad, 1 cm high, grayish green; filaments falsely branched in pairs or single, 16–18 (−22)μ broad; sheaths colourless, up to 3μ thick; trichomes 10–15μ broad; cells 3–6μ long; heterocysts 7–21μ long.

Geogr. Distrib.: Pacific Ocean.

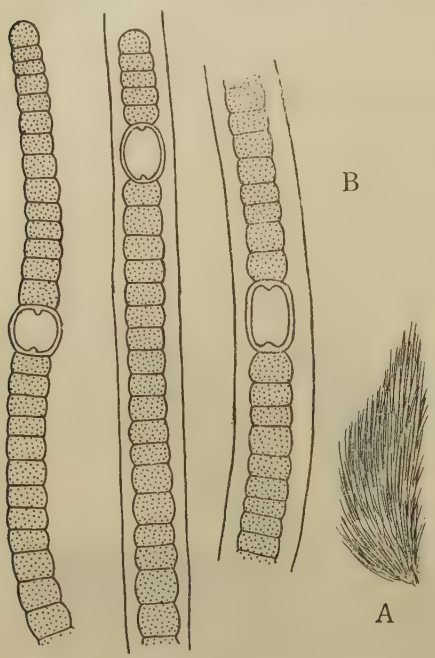


Fig. 5. *Hormothamnin enteromorphoides* GRUNOW.
A, habit of a frond. ×½. B, apical and middle portions of filaments. ×400.

Family Nostocaceae

Hormothamnion enteromorphoides GRUNOW

(Fig. 5)

Koniya: Floating or on *Hypnea cervicornis* and *Sargassum* sp. growing within one meter below low tide level (1757, 1772, 1824 a, 1826).

Plant mass bright blue-green, gelatinous, at first growing on large algae, later floating free; filaments nearly parallel with one another or irregularly arranged; sheaths colourless, diffluent sometimes, thin or sometimes becoming thicker while aging; trichomes blue-green, towards the ends sometimes attenuating slightly; cells nearly spherical or a little shorter than the diameter, 8–9μ broad, 4.5–7.5μ long; heterocysts quadrate or rectangular, 9–10.5μ broad, 10–15.5μ long; spores unknown.

In spite of careful observations from abundant materials the spores could not be found.

Geogr. Distrib.: Pacific Ocean, North America, Southern Asia, West Indies, North Africa.

Family Oscillatoriaceae

Spirulina tenerrima KUETZING

Yamma: In company with *Phormidium epiphyticum* on the sheaths of *Hydrocoleum glutinosum* (1745 b, 1750 b). Ushuku: In company with *Phormidium epiphyticum* on *Hydrocoleum lyngbyaceum* (1855 e).

Geogr. Distrib.: Probably cosmopolitan.

Oscillatoria Bonnemaisonii Crouan

Koniya: Among the fronds of other Cyanophyceae (1806 e).
Trichomes 20–30 μ broad; cells 4–6.5μ long.
Geogr. Distrib.: Probably cosmopolitan.

Oscillatoria chalybea Mertens

Koniya: Floating among the filaments of *Scytonema polycystum* and *Hydrocoleum cantharidosmum* (1758 c).

Only a few trichomes having a diameter of 13μ were found among the filaments of other blue-green algae.

Geogr. Distrib.: Cosmopolitan.

Oscillatoria nigro-viridis Thwaites

Asani: On rocks in the upper littoral zone (1704, 1708). Naze: On rocks or on other algae, *Caulacanthus* sp. and *Microdictyon japonicum* (1845, 1847, 1848, 1872). Gusuku: On rocks in the upper littoral zone (1716). Yamma: On other Cyanophycean masses growing on rocks near high tide level (1737 in part).

Geogr. Distrib.: Probably cosmopolitan.

Plectonema terebrans Bornet & Flahault

Asani: In company with *Mastigocoleus testarum* in oyster shells (1712 b). Ushuku: In company with *Mastigocoleus testarum* in a mollusc shell (1876 b).

Geogr. Distrib.: Probably cosmopolitan.

Plectonema norvegicum Gomont

(Fig. 6 A)

Asani: On *Calothrix crustacea* (1698 b). Gusuku: On *Calothrix crustacea* (1729 b). Yamma: On *Lyngbya semiplena* (1741 b).

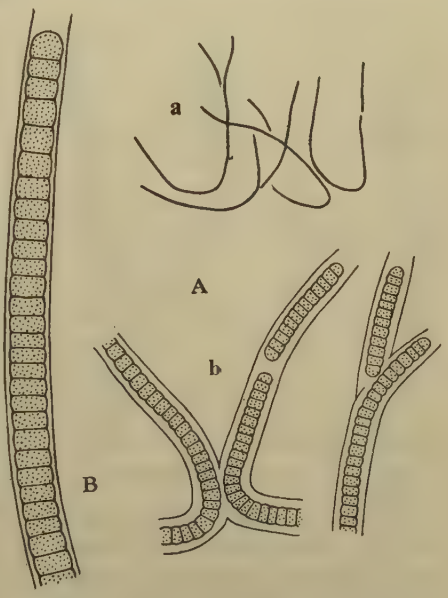


Fig. 6. A. *Plectonoma norvegicum* Gomont. a, habit of filaments. ×400. b, filament with geminate branching (left) and filament with single (right). ×1,000.
B. *Lyngbya gracilis* Rabenhorst. Upper portion of a filament. ×400.

Filaments densely intricated, mostly up to 100 μ long, irregularly curved, 2.5–3.5 μ broad, not attenuating towards the apex; sheaths colourless, thick; trichomes pale blue-green, 1.5–2 μ broad, constricted at the cross walls; cells $\frac{1}{2}$–1 time as long as the diameter; end cells rounded.

Though each local plant from three stations was found epiphytic instead of growing on rocks, they are identical with the characteristics of the species.

Geogr. Distrib.: Australia, Europe.

Plectonema calothrichoides GOMONT

Yamma: On *Gelidium* sp. (1744 in part). Gusuku: On *Nemalion pulvinatum* (1728 in part).

Filaments up to 300 μ long, sometimes branched in pairs, 4–5 μ broad; sheaths colourless; trichomes pale blue-green, 2.5–3.5 μ broad.

Geogr. Distrib.: Japan, North America, Europe.

Plectonema Nostocorum BORNET

(Fig. 7 A)

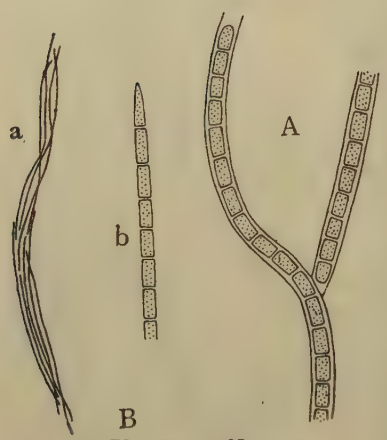


Fig. 7. *Plectonema Nostocorum* BORNET.
Filament with single branching. ×1,000. B. *Microcoleus Voukii* FRÉMY. a, habit of a filament. ×80. b, apical portion of a trichome. ×400.

Yamma: On *Ulva conglobata* (1736 in part).

Filaments intricated, elongate, sparsely branched; false-branches mostly single; sheaths colourless, thin; trichomes pale blue-green, 1–1.3 μ in diam., slightly constricted at the cross walls; dissepiments not granulated, a little pellucid; cells longer than the diameter, 2–2.5 μ in length; end cells rounded.

Geogr. Distrib.: Cosmopolitan.

Phormidium Corium (AGARDH) GOMONT ?

Koniya: On rocks in the lower littoral zone, associated with *Hydrocoleum cantharidosmum* (1785 b). Yamma: On concrete near high tide level (1738 in part).

Geogr. Distrib.: Cosmopolitan.

Phormidium epiphyticum GARDNER

Asani: On the sheaths of *Hydrocoleum cantharidosmum* (1706 b). Yamma: In company with *Spirulina tenerrima* on *Hydrocoleum glutinosum* (1745 c, 1750 c).

Ushuku: In company with *Spirulina tenerrima* on *Hydrocoleum lyngbyaceum* (1855 d).
Geogr. Distrib.: Japan, North America, West Indies.

Lyngbya Rivulariarum Gomont

Koniya: In the fronds of *Rivularia polyotis* (1796 b).
Geogr. Distrib.: Probably cosmopolitan.

Lyngbya infixa Frémy

Asani: On *Gelidium* sp. and *Bostrychia binderi* (1701 in part).
Geogr. Distrib.: Japan, West Indies, Europe.

Lyngbya Nordgardhii Wille

Gusuku: On *Gelidium* sp. (1726 in part).
Geogr. Distrib.: Japan, North America, West Indies, Europe.

Lyngbya gracilis Rabenhorst

(Fig. 6 B)

Asani: On *Caulacanthus* sp. (1709 in part). Koniya: On shaded rocks along high tide level (1913 a).

In the local plants the filaments were very short compared with the description by Gomont. Concerning the diameter and colour of the trichome and the cell-length these seem to be the nearest to this species.

Geogr. Distrib.: Japan, North America, West Indies, Europe.

Lyngbya sordida (Zanardini) Gomont

Koniya: On *Centroceras clavulatum* (1809). Ushuku: With filamentous diatoms on rocks in the upper littoral zone (1860, 1861).

In addition to the filaments having normal diameter, the specimen 1861 contains the filaments having the larger dimension from 52μ to 59μ, which seem to be the f. *maxima* mihi, although the trichome is yellowish-green instead of rose coloured. Such filaments were found in a mixture with those of typical form.

Geogr. Distrib.: Japan, Pacific Ocean, West Indies, Australia, Europe.

Lyngbya majuscula Harvey

Koniya: Associating with *Jania* sp. on rocks a little below low tide level (1823). Filaments up to 1 cm long, 37–61.4μ broad; sheaths 4.5–9μ thick; trichomes

28–43.5μ broad; cells 2.5–6μ long.

Geogr. Distrib.: Cosmopolitan.

Lyngbya confervoides C. AGARDH

Asani: On rocks in the lower littoral zone (1715). Koniya: Floating on the surface of sea (1765).

Geogr. Distrib.: Cosmopolitan.

Lyngbya semiplena (C. AGARDH) J. AGARDH

Naze: On concrete and rocks near high tide level (1840 a, 1841). Yamma: On rocks near high tide level (1736, 1741 a, 1743). Koniya: On rocks in the upper littoral zone (1760, 1790 c, 1798 a). Akakina: With *Calothrix crustacea* on rocks in the lower littoral zone (1864 c).

Geogr. Distrib.: Cosmopolitan.

Lyngbya lutea (AGARDH) GOMONT

Yamma: On rocks in a rock depression in the upper littoral zone (1749). Koniya: On rocks in a rock depression a little above high tide level (1816 a).

Geogr. Distrib.: Probably cosmopolitan.

Lyngbya aestuarii (MERTENS) LIEBMANN

Koniya: On rocks and on *Bostrychia binderi* growing on rocks in the upper littoral zone (1754 in part, 1756 a, 1763 a, 1764 a, 1784 a, 1806 a, 1816 b, 1822 a, 1883).

Geogr. Distrib.: Cosmopolitan.

Microcoleus tenerrimus GOMONT

Asani: Scattered among small red algae (1711 in part). Yamma: On *Ulva conglobata* (1736 in part); on concrete near high tide level (1738 in part); associating with *Hydrocoleum glutinosum* (1750 d). Koniya: Associating with *Microcoleus chthonoplastes* and *Hydrocoleum lyngbyaceum* (1803 c); with *Lyngbya aestuarii* (1806 c); with *Microcoleus chthonoplastes* on rocks in the upper littoral zone (1815 b). Ushuku: With *Microcoleus chthonoplastes* and *Hydrocoleum lyngbyaceum* (1855 c). Akakina: With *Microcoleus chthonoplastes* on rocks in the upper littoral zone (1866 b, 1870 d).

Geogr. Distrib.: Cosmopolitan.

Microcoleus chthonoplastes THURET

Ushuku: With *Microcoleus tenerrimus* and *Hydrocoleum lyngbyaceum* on rocks

along high tide level (1855 b). Akakina: With *Microcoleus tenerrimus* on rocks in the upper littoral zone (1866 a, 1870 c). Koniya: Among the filaments of *Calothrix pilosa* (1753 b, 1807 b); On rocks and *Bostrychia binderi* growing on rocks along high tide level (1755 in part); among the fronds of *Hydrocoleum lyngbyaceum* (1803 b); with *Lyngbya aestuarii* (1806 b); with *Microcleus tenerrimus* on rocks in the upper littoral zone (1815 a). Naze: On *Bostrychia binderi* (1844). Asani: On shaded rocks in the upper littoral zone (1700 a).

Geogr. Distrib.: Cosmopolitan.

Microcoleus Voukii Frémy

(Fig. 7 B)

Gusuku: Among the utricles of *Codium intricatum* (1732).

Filaments endophytic, simple or sparsely branched; sheaths colourless, mostly diffluent; trichomes pale blue-green, 1.6–1.8μ broad, not constricted at the cross walls; dissepiments pellucid, not granulated; cells 3.2–9μ long; protoplast homogeneous; end cells sharply conical.

According to Frémy, this species bears the nearest resemblance to *Microcoleus tenerrimus*, from which he distinguished it only by the characteristics that the trichome is purple in colour and not constricted at the cross walls. The trichome of this local plant is pale blue-green and nearly resembling *M. tenerrimus*, although it was found endophytic.

Geogr. Distrib.: Europe.

Hydrocoleum lyngbyaceum Kuetzing

Koniya: Associated with *Microcoleus chthonoplastes* and *M. tenerrimus* on rocks a little below high tide level (1803 a); On *Hypnea cervicornis* (1824 b). Ushuku: With *Microcoleus tenerrimus* and *M. chthonoplastes* on rocks along high tide level (1855 a). Akakina: In company with *Microcoleus chthonoplastes* and *M. tenerrimus* (1866 c). Yamma: On rocks in the upper littoral zone (1747 in part).

Geogr. Distrib.: Cosmopolitan.

Hydrocoleum cantharidosmum (Montagne) Gomont

Asani: On rocks in the upper littoral zone (1706 a). Gusuku: On rocks in the lower littoral zone (1726 in part). Koniya: Among the masses of *Scytonema polycystum* (1758 b); on rocks in the lower or upper littoral zone (1763 b, 1769, 1773, 1783 a, 1789, 1805, 1811, 1820, 1822 b).

Geogr. Distrib.: Japan, Southern Asia, Pacific Ocean, West Indies, Australia.

Hydrocoleum glutinosum (AGARDH) GOMONT

Yamma: On rocks in the upper littoral zone (1745 a, 1750 a). Koniya: On rocks a little above high tide level (1814). Naze: On rocks in the upper littoral zone (1851).

Geogr. Distrib.: Japan, Pacific Ocean, North America, West Indies, Australia, Europe, Indian Ocean.

Hydrocoleum coccineum GOMONT

Asani: Among the utricles of *Codium adhaerens* (1710). Gusuku: Among the utricles of *Codium adhaerens* (1734). Koniya: Among the utricles of *Codium adhaerens* (1835). Ushuku: Among the utricles of *Codium adhaerens* (1878).

All of the alga from Amami-Oshima have the trichomes 3–4.5μ or 5.5μ in diameter, a little more slender than those of the original specimen cited by GOMONT.

Geogr. Distrib.: Japan, Pacific Ocean, North America, Indian Ocean, Europe.

Symploca hydnoides KUETZING

Asani: On rocks in the upper littoral zone (1705). Naze: On rocks in the upper littoral zone (1849). Gusuku: On rocks in the upper littoral zone (1718).

The local specimens are forming fasciculated tufts 1–4 cm high.

Geogr. Distrib.: Cosmopolitan.

VII. Summary

1. This paper deals with the floristic, ecological and phytogeographical studies on the marine Cyanophyceae of Amami-Oshima island.

2. 7 families, 21 genera, 51 species are enumerated, among them 7 species being new to Japan.

3. The stations visited to collect the material are the following seven localities: Naze, Asani, Akakina, Ushuku, Yamma, Gusuku, and Koniya. Among these stations the Koniya coast is best not only in being plentiful in the marine flora but also for the convenience of collecting the material.

4. On the basis of the ecological variation in habit, the species of Amami-Oshima island are classified into the following five forms: (1) planktonic form, (2) lithophytic form, (3) epiphytic form, (4) endophytic form, and (5) shell-perforating form. 5 species belong to the planktonic form, 25 to the lithophytic form, 14 to the epiphytic form, 4 to the endophytic form, and 3 to the shell-perforating form.

5. *Coccochloris stagnina*, *Anacystis dimidiata*, *Agmenellum thermale*, *Calothrix balearica*, *Spirulina tenerrima*, *Oscillatoria chalybea*, *Plectonema Nostocorum*, *Phormidium Corium*, *Lyngbya lutea*, *L. aestuarii*, and *L. Rivulariarum* whose habitats are

generally in fresh water, although they occasionally grow in marine water, are included here.

6. 29 cosmopolitan or probably cosmopolitan species, which grow also on the coast of Honshu, are recorded.

7. 42 of these species have already been reported from Japan proper, 24 from Hokkaido, 2 from the China coast, 17 from Southeast Asia, 34 from the warmer Pacific Ocean, 37 from the Pacific coast of North America, 37 from the West Indies, 21 from Australia, and 43 from Europe.

8. *Gardnerula corymbosa*, *Fremyella vitiensis*, *Scytonema polycystum*, and *Hormothamnion enteromorphoides* which seem to be of tropical origin, are listed here.

9. From the phytogeographical standpoint, the marine Cyanophycean composition of Amami-Oshima island is considered to be subtropical.

VIII. Acknowledgements

Here the writer wishes to express his sincere thanks to Dr. Y. YONEDA of the Department of Fisheries, Faculty of Agriculture, Kyoto University, who gave him most kind guidance during the course of this study. Thanks are also due to Dr. F. DROUET of the Cryptogamic Herbarium, Chicago Natural History Museum, Chicago, who sent him a number of the specimens of *Symploca hydnoides* and *Gardnerula corymbosa* from various localities in the world and gave him valuable suggestions in determining the present species, and who read this manuscript.

REFERENCES

BATTERS, E. A. 1902. A catalogue of the British marine algae. Journ. of Bot. 40 (supplement 1) : 1–107.

BORNET, E., & C. FLAHAULT. 1886–1888. Révision des Nostocacées hétérocystées contenues dans les principaux herbiers de France. Ann. Sc. Nat. VII, Bot. 3 : 323–380 ; 4 : 343–373 ; 5 : 51–129 ; 7 : 177–268.

DAWSON, E. A. 1954. Marine plants in the vicinity of the Institut Oceanographique de Nha Trang, Viet Nam. Pac. Sci. 8 (4) : 377–469.

DE TONI, J. 1936. Noterelle di nomenclatura algologica. VIII. Terzo elenco di Missoficee omonime. 1–6. Brescia.

DROUET, F. 1936. Myxophyceae of the G. Allan Hancock Expedition of 1934, collected by Wm. R. Taylor. Hancock Pac. Exped. 3 (2) : 15–31, pls. 2–3.

———— 1951. Cyanophyta, in SMITH's Manual of Phycology, 159–166.

DROUET, F., & W. A. DAILY. 1956. Revision of the coccoid Myxophyceae. Butler Univ. Bot. Stud. 12 : 1–218, 377 figs.

FELDMANN, J. 1937. Les algues marines de la côte des Alberes. I. Cyanophyceae. Rev. Algol. 9 (3–4) : 141–172.

FRÉMY, P. 1934. Les Cyanophycées des côtes d'Europe. Mém. Soc. Nat. Sc. nat. et math. de Cherbourg. 41 : 1–234, 66 pls.

———— 1936. Marine algae from the Canary Islands, especially from Teneriffe and Gran Canaria. IV. Cyanophyceae. Kgl. Dansk. Vidensk. Sels. Biol. Meddel. 12 (5) : 4–43.

———— 1939. Cyanophycées marines des anciennes Antilles Danoises, in BOERGESEN's Marine algae of the Danish West Indies. Dansk. Botanik Arkiv. 9 (7) : 5–46.

———— 1941. Cyanophycées des Iles Bonaire, Curacae et Aruba d'aprés les recoltes de M. Wagenaar Hummelink (Utrecht) en 1930. Rev. Algol. 12 (1–2) : 102–152.

GARDNER, N. L. 1918. New Pacific coast marine algae. I–IV. Univ. Calif. Publ. Bot. 6 : 377–416, pls. 31–35 ; 429–454, pls. 36–37 ; 455–486, pls. 38–41 ; 487–496, pl. 42.

———— 1932. The Myxophyceae of Porto Rico and the Virgin Islands. Surv. of Porto Rico and the Virgin Isl. 8 (2) : 249–311, pls. 1–2.

GEITLER, L. 1932. Cyanophyceae, in RABENHORST'S Kryptogamen-Flora von Europa. 14 : 1–1196, 780 figs. Leipzig.

GOMONT, M. 1892. Monographie des Oscillariées (Nostocacées homocystées). Ann. Sc. Nat. VII. Bot. 15 : 263–369, pls. 6–14 ; 16 : 91–264, pls. 1–5.

———— 1899. Sur quelques Oscillariées nouvelles. Bull. Soc. Bot. de France 46 (24) : 25–40, pl. 1.

———— 1901. Myxophyceae hormogoneae, in SCHMIDT'S Flora of Koh Chang. Bot. Tidsskr. 24 : 202–211, pl. 1.

GUILER, E. R. 1952. The marine algae of Tasmania, check list with localities. Pap. & Proc. Roy. Soc. Tasmania 86 : 71–106.

JAO, C.-C. 1948. The marine Myxophyceae in the vicinity of Friday Harbor, Washington. Bot. Bull. Acad. Sinica 2 : 161–176, fig. 1.

LINDSTEDT, A. 1943. Die Flora der marinen Cyanophyceen du schwedischen Westkueste. viii–121, 11 pls.

MAY, V. 1953. Some marine algae from New Caledonia collected by Mrs. R. Catala. Contrib. New South Wales Nat. Herb. 2 (1) : 38–66.

MOELDER, K. 1945. Die Cyanophyceenflora Estlands. Ann. Bot. Soc. Zool.-Bot. Fenn. Vanamo. 20 (4) : 1–21.

NEWTON, L. 1931. A handbook of the British seaweeds. xiii–478, 270 figs. London.

NIEL, M. C. 1930. Hawaiian marine algae. Bernice P. Bishop Museum Bulletin 67 : ii–84.

SETCHELL, W. A. 1926. Tahitian algae collected by W. A. Setchell, C. B. Setchell, and H. E. Parks. Univ. Calif. Publ. Bot. 12 (5) : 61–142, pls. 7–22.

SETCHELL, W. A., & N. L. GARDNER. 1903. Algae of Northwestern America. *Ibid.* 1 : 154–418, 21 pls.

———— . ———— 1919. The marine algae of the Pacific coast of North America. Part 1. Myxophyceae. *Ibid.* 8 (1) : 1–138, pls. 1–18.

———— . ———— 1924. New marine algae from the gulf of California. Proc. Calif. Acad. of Sc. Ser. IV. 12 (29) : 659–704, pl. 12.

TAYLOR, WM. R. 1942. Marine algae from Haiti collected by H. H. Bartlett in 1914. Rep. of Michigan Acad. Sc. Arts and Letters, 28 : 143–163, pls. 1–4.

———— 1945. Pacific marine algae of the Allan Hancock Expedition to the Galapagos Island. Allan Hancock Pac. Exped. 12 (1) : iv–528, 100 pls.

———— 1950. Plants of Bikini and other northern islands. 1–227. Ann Arbor.

TSENG, C. K. 1936. On marine algae new to China. Fan Mem. Inst. Biol. Bull. (Bot). 7 (5) : 169–196.

———— 1940. Marine algae of Hong Kong, historical survey and list of recorded species. Journ. Hong Kong Fish Res. Stat. 1 (2) : 194–210.

TILDEN, J. 1910. Minnesota Algae. I. The Myxophyceae of North America and adjacent regions including Central America, Greenland, Bermuda, the West Indies and Hawaii. Rep. Surv. Bot. Ser. 8 : iv–328, 20 pls.

UMEZAKI, I. 1950–1956a. Marine Cyanophyceae from Japan (1–12). Journ. Jap. Bot. 25 (9–12) : 224–228 ; 26 (7) : 203–205 ; 26 (9) : 267–269 ; 27 (4) : 117–120 ; 27 (7) : 219–222 ; 28 (6) : 165–170 ; 28 (7) : 201–203 ; 28 (8) : 236–239 ; 28 (12) : 363–366 ; 29 (6) : 172–176 ; 29 (7) : 217–220 ; 31 (2) : 33–36. [In Japanese]

———— 1955a. Marine Cyanophyceae from the Shima Peninsula (1–2). *Ibid.* 30 (2) : 57–62 ; 30 (7) : 209–214.
———— 1955b. Some marine Cyanophyceae of the Tokara Islands. Bot. Mag. Tokyo 68 (801) : 63–70.
———— 1956b. Marine Cyanophyceae from Hokkaido. Acta Phytotax. Geobot. 16 (3) : 84–90. [In Japanese]
———— 1956c. On a collection of *Gardnerula corymbosa* (Harvey) J. de Toni. Publ. Seto Mar. Biol. Lab. 5 (2) : 291–295.
WEBER-VAN BOSSE, A. 1913. Liste des algues du Siboga. I. Myxophyceae, Chlorophyceae, Phaeophyceae avec le concours de M. Th. Reinbold. Siboga-Exped. Monogr. 59(a) : 1–186, figs. 1–52, pls. 1–5.
———————— 1926. Algues de l'expedition danois aux iles Kei. Vidensk. Meddel. Dansk Naturh Foren. 81 : 57–155, 43 figs.
WOMERSLEY, H. B. 1946. Studies on the marine algae of the Southern Australia. Introduction and No. 1. The genera *Isactis* and *Rivularia* (Myxophyceae). Trans. Roy. Soc. S. Aust. 70 (1) : 127–136.
———————— 1950. The marine algae of Kangaroo island. III. List of species I. *Ibid.* 73 (2) : 137–197.

PUBLICATIONS OF THE SETO MARINE BIOLOGICAL LABORATORY

Volume I

No. 1 (Article 1). (out of print) ..... issued on May 31, 1949.
No. 2 (Article 2 to 4) ..... issued on December 25, 1949.
No. 3 (Article 5 to 9) ..... issued on October 5, 1950.
No. 4 (Article 10 to 14) ..... issued on May 31, 1951.

Volume II

No. 1 (Article 1 to 2) ..... issued on October 20, 1951.
No. 2 (Article 3 to 21 and record of works between 1922 and 1951) (Jubilee number) ..... issued on October 5, 1952.

Volume III

No. 1 (Article 1 to 8) ..... issued on July 30, 1953.
No. 2 (Article 9 to 21 and record of works for 1952) ... issued on December 20, 1953.
No. 3 (Article 22 to 32) ..... issued on May 30, 1954.

Volume IV

No. 1 (Article 1 to 14 and record of works for 1953) ... issued on November 20, 1954.
Nos. 2 & 3 (Article 15 to 35) ..... issued on May 30, 1955.

Volume V

No. 1 (Article 1 to 7) ..... issued on December 20, 1955.
No. 2 (Article 8 to 18 and record of works for 1954) ..... issued on June 30, 1956.

昭和31年12月15日印刷
昭和31年12月20日発行

非賣品

編集兼発行者
瀬戸臨海実験所
和歌山県西牟婁郡白浜町
電話白浜温泉47番

印刷所 日本印刷出版株式会社
大阪市福島区亀甲町2丁目62

印刷者 小林積造
大阪市福島区亀甲町2丁目62